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(54) Title: NOVEL BGP COMPOUNDS FOR THERAPY AND DIAGNOSIS AND METHODS FOR USING SAME

(57) Abstract: The present invention provides methods and compositions for detecting, diagnosing, prognosing and monitoring the progress of BGP-related cancers and malignancies and kits for use in said methods. Further provided are methods for screening to identify agonists and antagonists of cancer antigens associated with BGP-related cancers and malignancies.

NOVEL BGP COMPOUNDS FOR THERAPY AND DIAGNOSIS AND METHODS FOR USING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. § 119 (e) to U.S. Provisional Application Serial No. 60/281,576, filed April 4, 2001, the content of which is incorporated by reference into the present disclosure.

TECHNICAL FIELD

The invention relates to compounds useful in therapeutic, diagnostic and screening methods for human cancers and related malignancies.

BACKGROUND OF THE INVENTION

The number of people dying each year from cancer continues to rise. The most common causes of cancer death for men and women in the United States are, in order, cancers of the lung, colon, and breast. While there have been some modest objective improvements in the survival of patients with these diseases over the past few decades, the rising incidence more than compensates for this and the total number of deaths continues to rise.

Lung cancer is the most common form of cancer in the world. Typical diagnosis of lung cancer combines x-ray with sputum cytology. Unfortunately, by the time a patient seeks medical attention for their symptoms, the cancer is at such an advanced state it is usually incurable. Consequently, research has been focused on early detection of tumor markers before the cancer becomes clinically apparent and while the cancer is still localized and amenable to therapy. Mulshine, et al., "Applications of monoclonal antibodies in the treatment of solid tumors," In: BIOLOGIC THERAPY OF CANCER. Edited by V. T. Devita, S. Hellman, and S. A. Rosenberg. Philadelphia: J B Lippincott, 1991, pp. 563-588.

Colorectal cancer is the third most common malignant neoplasm worldwide, and the second leading cause of cancer deaths in the United States. Shike, M., Winawer, S.J., Greenwald, P.H., et al., (1990) Primary Prevention of Colorectal Cancer: the WHO Collaborating Centre for the Prevention of Colorectal Cancer; Bulletin of the WHO **68**(3):377-85; Greenlee, R.T. et al., (2001) Cancer Statistics, 2001. CA: A Cancer Journal

for Clinicians **51**(1):15-36. It is estimated that there will be 135,400 new cases and 56,700 deaths related to the disease in the United States. Approximately 65% of patients present with advanced disease.

Breast cancer is a major medical problem for women beginning in the third decade of life and continuing throughout senescence. It is currently estimated that in the United States women have a one in eight chance of developing the disease in their lifetime (by the age of eighty), whereas one in twenty-eight women have a lifetime risk of dying from breast cancer. Harris et. al., Ed. DISEASES OF THE BREAST, 1996: pp. 159-168. Breast carcinoma is the second most common cause of cancer death in women in the United States, and for women between the ages of 15 and 54, the leading cause of cancer-related death. (Forbes (1997) Seminars in Oncology **24**(1), Suppl. 1, pp.S1-20-S1-35).

Prostate cancer is the most common malignant cancer in North American men (excluding skin). It is estimated that in 2001, approximately 198,100 new cases and 31,500 prostate cancer-related deaths will occur in the United States. Greenlee, R.T. et al., *supra.* Prostate cancer is now the second leading cause of cancer death in men, exceeded only by lung cancer. It accounts for 29% of all male cancers and 11% of male cancer-related deaths.

Ovarian cancer is the fifth leading cause of cancer death among women in the United States and has the highest mortality rate of all gynecologic cancers. Greenlee, R.T. et al., (2001) *supra.* It is projected for 2001 that 23,400 new cases of ovarian cancer will be diagnosed and 13,900 women will die of the disease. Greenlee, R.T. et al., (2001) *supra.* The prognosis for survival from ovarian cancer is largely dependent upon the extent of disease at diagnosis. Women diagnosed with local disease are over 3 times more likely to survive 5 years than women with distant disease. However, only one fourth of women present with localized disease at diagnosis. Ries, L.A. et al., (1998), SEER Cancer Statistics Review 1973-1995, Bethesda, MD: National Cancer Institute.

Melanomas make up approximately three percent of all skin cancers and the worldwide increase in melanoma is unsurpassed by any other neoplasm with the exception of lung cancer in women. CELLULAR AND MOLECULAR IMMUNOLOGY (1991) (eds) Abbas, A. K., Lechtiman, A. H., Pober, J. S.; W.B. Saunders Company Philadelphia, pages: 340-342; Kirkwood and Agarwala (1993) Principles and Practice of Oncology **7**:1-16. Even when melanoma is apparently localized to the skin, up to 30% of the patients will develop systemic metastasis and the majority will die. Kirkwood and Agarwala (1993) Principles and Practice of Oncology **7**:1-16.

One of the major goals of cancer immunotherapy is the induction of tumor-specific T-lymphocyte responses that will be effective in the rejection of established tumors. The prospects for such therapies rely on the identification and characterization of tumor-specific immune responses.

The recognition of antigenic epitopes presented by molecules of the Major Histocompatibility Complex (MHC) plays a central role in the establishment, maintenance and execution of mammalian immune responses. T cell surveillance and recognition of peptide antigens presented by cell surface MHC molecules expressed by somatic cells and antigen presenting leukocytes functions to control invasion by infectious organisms such as viruses, bacteria, and parasites. In addition it has now been demonstrated that antigen-specific cytotoxic T lymphocytes (CTLs) can recognize certain cancer cell antigens and attack cells expressing these antigens. This T cell activity provides a basis for developing novel strategies for anti-cancer vaccines. Furthermore, inappropriate T cell activation plays a central role in certain debilitating autoimmune diseases such as rheumatoid arthritis, multiple sclerosis, and asthma. Thus presentation and recognition of antigenic epitopes presented by MHC molecules play a central role in mediating immune responses in multiple pathological conditions.

Tumor specific T cells, derived from cancer patients, will bind and lyse tumor cells. This specificity is based on their ability to recognize short amino acid sequences (epitopes) presented on the surface of the tumor cells by MHC class I and, in some cell types, class II molecules. These epitopes are derived from the proteolytic degradation of intracellular proteins called tumor antigens encoded by genes that are either uniquely or aberrantly expressed in tumor or cancer cells.

The availability of specific anti-tumor T cells has enabled the identification of tumor antigens and subsequently the generation of cancer vaccines designed to provoke an anti-tumor immune response. Anti-tumor T cells are localized within cancer patients, including in the blood (where they can be found in the peripheral blood mononuclear cell fraction), in primary and secondary lymphoid tissue, *e.g.*, the spleen, in ascites fluid in ovarian cancer patients (tumor associated lymphocytes or TALs) or within the tumor itself (tumor infiltrating lymphocytes or TILs). Of these, TILs have been the most useful in the identification of tumor antigens and tumor antigen-derived peptides recognized by T cells.

Conventional methods to generate TILs involve mincing tumor biopsy tissue and culturing the cell suspension *in vitro* in the presence of the T cell growth factor interleukin-2 (IL-2). Over a period of several days, the combination of the tumor cells and IL-2 can

stimulate the proliferation of tumor specific T cells at the expense of tumor cells. In this way, the T cell population is expanded. The T cells derived from the first expansion are subsequently mixed with either mitomycin C-treated or irradiated tumor cells and cultured *in vitro* with IL-2 to promote further proliferation and enrichment of tumor reactive T cells. After several rounds of *in vitro* expansion, a potent anti-tumor T cell population can be recovered and used to identify tumor antigens via conventional but tedious expression cloning methodology. Kawakani Y. et al. (1994) Proc. Natl. Acad. Sci. USA **91**(9):3515-3519.

This currently employed methodology used to generate tumor specific T cells *in vitro* is unreliable and the antigens identified by this method do not necessarily induce an anti-tumor immune response. Numerous experiments demonstrate that the encounter of antigens by mature T cells often results in the induction of tolerance because of ignorance, anergy or physical deletion. Pardoll (1998) Nature Med. **4**(5):525-531.

The ability of a particular peptide to function as a T cell epitope requires that it bind effectively to the antigen presenting domain of an MHC molecule and also that it display an appropriate set of amino acids that can be specifically recognized by a T cell receptor molecule. While it is possible to identify natural T cell epitopes derived from antigenic polypeptides, these peptide epitopes do not necessarily represent antigens that are optimized for inducing a particular immune response. In fact, it has been shown that it is possible to improve the effectiveness of natural epitopes by introducing single amino or multiple acids substitutions that alter their sequence (Valmori et al. (2000) J. Immunol **164(2)**:1125-1131). Thus, delivery of carefully optimized peptide epitopes has the potential to provide an improved method to induce a useful immune response.

The introduction into an animal of an antigen has been widely used for the purposes of modulating the immune response, or lack thereof, to the antigen for a variety of purposes. These include vaccination against pathogens, induction of an immune response to a cancerous cell, reduction of an allergic response, reduction of an immune response to a self antigen that occurs as a result of an autoimmune disorder, reduction of allograft rejection, and induction of an immune response to a self antigen for the purpose of contraception.

More recently, certain pathogen- and tumor-related proteins have been immunologically mimicked with peptides whose amino acid sequence corresponds to that of a known or predicted antigenic determinant domain of the pathogen- or tumor-related protein. Despite these advances, such peptide mimics generally perform less than optimally with respect to inducing an immune response.

Despite the numerous examples of isolated antigens and other biomarkers shown to be associated with various cancers, the usefulness of such tools for therapeutic diagnostic, prognostic and other detection applications are limited, for example, in that they have been shown to be ineffective, unreliable, lacking in sensitivity and/or predictiveness, and the like. Thus, there exists a continuing need to identify antigens, antigenic epitopes and other biomarkers associated with cancer and to develop new materials and kits to aid in the early detection, therapy and monitoring of related cancers. The present invention satisfies this need and provides related advantages as well.

DISCLOSURE OF THE INVENTION

The present invention provides novel compounds and methods for the therapy and diagnosis of BGP related cancers and malignancies.

Further provided are polynucleotides encoding the compounds of the invention, the nucleic acid sequences provided in SEQ ID NOs: 1, 4, 6, 8, and 10, complements and variants thereof are also encompassed by the invention. Also provided are gene delivery vehicles and/or host cells comprising these polynucleotides.

Also provided by the invention are polypeptides encoded by the polynucleotides of the invention, and includes the amino acid sequences MLPVHFYGRV (SEQ ID NO. 3), FLPQFMLVV (SEQ ID NO. 5), FLHLHYYWV (SEQ ID NO. 7) and FLKADQYEV (SEQ ID NO. 9).

In addition, the invention provides methods for inducing an immune response in a subject by delivering the compounds and compositions of the invention, and delivering these in the context of an MHC molecule.

The compounds of the invention are also useful to generate antibodies that specifically recognize and bind to these molecules. These antibodies are further useful for immunotherapy when administered to a subject.

The invention also provides immune effector cells raised *in vivo* or *in vitro* in the presence and at the expense of an antigen presenting cell that presents the peptide compositions of the invention in the context of an MHC molecule and a method of adoptive immunotherapy comprising administering an effective amount of these immune effector cells to a subject.

Also provided by this invention is a composition comprising at least one immunogenic ligand, wherein said immunogenic ligand is individually characterized by an ability to elicit an immune response against the corresponding native ligand, and wherein

said immunogenic ligand comprises a sequence selected from the group consisting of SEQ ID NOs: 2, 3, 5, 7, and 9. The compositions can be combined with a carrier such as a pharmaceutically acceptable carrier.

Further provided by this invention is a host cell comprising at least one immunogenic ligand, wherein said immunogenic ligand is individually characterized by an ability to elicit an immune response against the corresponding native ligand, and wherein said immunogenic ligand comprises a sequence selected from the group consisting of SEQ ID NOs: 2, 3, 5, 7, and 9. In one aspect, the host cell is an antigen presenting cell, *e.g.*, a dendritic cell. Compositions comprising such host cells and a carrier such as a pharmaceutically acceptable carrier.

Further provided by this invention is a method for inducing an immune response in a subject by delivering to the subject a composition comprising an effective amount of at least one immunogenic ligand, wherein each of said immunogenic ligand is characterized by an ability to elicit an immune response against the corresponding native ligand, and wherein said immunogenic ligand is selected from the group of compounds comprising the sequences of SEQ ID NOs: 2, 3, 5, 7, and 9.

The present invention additionally provides methods and compositions for detecting, diagnosing, prognosing and monitoring the progress of BGP-related cancers and malignancies and kits for use in said methods.

Further provided are methods for screening to identify agonists and antagonists of cancer antigens associated with BGP-related cancers and malignancies.

The methods and compositions utilized to practice the method described herein are particularly suited to be adapted to automation and high-throughput assay systems.

DESCRIPTION OF THE SEQUENCE LISTINGS

SEQ ID NO:1. The complete nucleotide sequence of a cDNA encoding the human cancer antigen Brain Type Glycogen Phosphorylase ("BGP") (GenBank Accession No. J03544).

SEQ ID NO:2. The amino acid sequence of the native human cancer antigen Brain Type Glycogen Phosphorylase ("BGP") (GenBank Accession No. J03544).

SEQ ID NO:3. The amino acid sequence of compound 1. The peptide corresponds to amino acid residues 198 through 207 of native BGP (SEQ ID NO: 2).

SEQ ID NO:4. The polynucleotide sequences encoding compound 1.

SEQ ID NO:5. The amino acid sequence of compound 2.

SEQ ID NO:6. The polynucleotide sequences encoding compound 2.

SEQ ID NO:7. The amino acid sequence of compound 3.

SEQ ID NO:8. The polynucleotide sequences encoding compound 3.

SEQ ID NO:9. The amino acid sequence of compound 4.

SEQ ID NO:10. The polynucleotide sequences encoding compound 4.

MODES OF CARRYING OUT THE INVENTION

Throughout this disclosure, various publications, patents and published patent specifications are referenced by an identifying citation. The disclosures of these publications, patents and published patent specifications are hereby incorporated by reference into the present disclosure to more fully describe the state of the art to which this invention pertains.

The practice of the present invention employs, unless otherwise indicated, conventional techniques of molecular biology (including recombinant techniques), microbiology, cell biology, biochemistry and immunology, which are within the skill of the art. Such techniques are explained fully in the literature. These methods are described in the following publications. See, *e.g.*, Sambrook et al. MOLECULAR CLONING: A LABORATORY MANUAL, 2nd edition (1989); CURRENT PROTOCOLS IN MOLECULAR BIOLOGY (F. M. Ausubel et al. eds. (1987)); the series METHODS IN ENZYMOLOGY (Academic Press, Inc.); PCR: A PRACTICAL APPROACH (M. MacPherson et al. IRL Press at Oxford University Press (1991)); PCR 2: A PRACTICAL APPROACH (M.J. MacPherson, B.D. Hames and G.R. Taylor eds. (1995)); ANTIBODIES, A LABORATORY MANUAL (Harlow and Lane eds. (1988)); USING ANTIBODIES, A LABORATORY MANUAL (Harlow and Lane eds. (1999)); and ANIMAL CELL CULTURE (R.I. Freshney ed. (1987)).

Definitions

As used herein, certain terms may have the following defined meanings.

As used in the specification and claims, the singular form "a," "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a cell" includes a plurality of cells, including mixtures thereof.

As used herein, the term "comprising" is intended to mean that the compositions and methods include the recited elements, but do not exclude others. "Consisting essentially of" when used to define compositions and methods, shall mean excluding other elements of any essential significance to the combination. Thus, a composition consisting essentially of the elements as defined herein would not exclude trace contaminants from the isolation and purification method and pharmaceutically acceptable carriers, such as phosphate buffered saline, preservatives, and the like. "Consisting of" shall mean excluding more than trace elements of other ingredients and substantial method steps for administering the compositions of this invention. Embodiments defined by each of these transition terms are within the scope of this invention.

A "native" or "natural" or "wild-type" antigen is a polypeptide, protein or a fragment which contains an epitope, which has been isolated from a natural biological source, and which can specifically bind to an antigen receptor, in particular a T cell antigen receptor (TCR), in a subject.

The term "antigen" is well understood in the art and includes substances which are immunogenic, *i.e.*, immunogens, as well as substances which induce immunological unresponsiveness, or anergy, *i.e.*, anergens.

An "altered or modified antigen" is one having a primary sequence that is different from that of the corresponding wild-type antigen. Altered antigens can be made by synthetic or recombinant methods and include, but are not limited to, antigenic peptides that are differentially modified during or after translation, *e.g.*, by phosphorylation, glycosylation, cross-linking, acylation, proteolytic cleavage, linkage to an antibody molecule, membrane molecule or other ligand. (Ferguson et al. (1988) Ann. Rev. Biochem. **57**:285-320). A modified or altered antigenic epitope of the invention is intended to bind to the same TCR as the native or wild-type epitope.

A "self-antigen" also referred to herein as a native or wild-type antigen is an antigenic peptide that induces little or no immune response in the subject due to self-tolerance to the antigen. An example of a self-antigen is the melanoma specific antigen gp100.

The term "tumor associated antigen" or "TAA" refers to an antigen that is associated with or specific to a tumor. Examples of known TAAs include gp100, MART and MAGE.

The terms "major histocompatibility complex" or "MHC" refers to a complex of genes encoding cell-surface molecules that are required for antigen presentation to T cells and for rapid graft rejection. In humans, the MHC is also known as the "human leukocyte

antigen" or "HLA" complex. The proteins encoded by the MHC are known as "MHC molecules" and are classified into class I and class II MHC molecules. Class I MHC includes membrane heterodimeric proteins made up of an α chain encoded in the MHC noncovalently linked with the β_2-microglobulin. Class I MHC molecules are expressed by nearly all nucleated cells and have been shown to function in antigen presentation to $CD8^+$ T cells. Class I molecules include HLA-A, B, and C in humans. Class II MHC molecules also include membrane heterodimeric proteins consisting of noncovalently associated α and β chains. Class II MHC molecules are known to function in $CD4^+$ T cells and, in humans, include HLA-DP, -DQ, and DR. In a preferred embodiment, invention compositions and ligands can complex with MHC molecules of any HLA type. Those of skill in the art are familiar with the serotypes and genotypes of the HLA. See: bimas.dcrt.nih.gov/cgi-bin/molbio/hla coefficient viewing page. Rammensee H.G., Bachmann J., and Stevanovic S. MHC Ligands and Peptide Motifs (1997) Chapman & Hall Publishers; Schreuder G.M. Th. et al. The HLA dictionary (1999) Tissue Antigens **54**:409-437.

The term "antigen-presenting matrix", as used herein, intends a molecule or molecules which can present antigen in such a way that the antigen can be bound by a T-cell antigen receptor on the surface of a T cell. An antigen-presenting matrix can be on the surface of an antigen-presenting cell (APC), on a vesicle preparation of an APC, or can be in the form of a synthetic matrix on a solid support such as a bead or a plate. An example of a synthetic antigen-presenting matrix is purified MHC class I molecules complexed to β_2-microglobulin, multimers of such purified MHC class I molecules, purified MHC Class II molecules, or functional portions thereof, attached to a solid support.

The term "antigen presenting cells (APC)" refers to a class of cells capable of presenting one or more antigens in the form of antigen-MHC complex recognizable by specific effector cells of the immune system, and thereby inducing an effective cellular immune response against the antigen or antigens being presented. While many types of cells may be capable of presenting antigens on their cell surface for T-cell recognition, only professional APCs have the capacity to present antigens in an efficient amount and further to activate T-cells for cytotoxic T-lymphocyte (CTL) responses. APCs can be intact whole cells such as macrophages, B-cells and dendritic cells; or other molecules, naturally occurring or synthetic, such as purified MHC class I molecules complexed to β2-microglobulin.

The term "dendritic cells (DC)" refers to a diverse population of morphologically similar cell types found in a variety of lymphoid and non-lymphoid tissues (Steinman (1991) Ann. Rev. Immunol. 9:271-296). Dendritic cells constitute the most potent and preferred APCs in the organism. A subset, if not all, of dendritic cells are derived from bone marrow progenitor cells, circulate in small numbers in the peripheral blood and appear either as immature Langerhans' cells or terminally differentiated mature cells. While the dendritic cells can be differentiated from monocytes, they possess distinct phenotypes. For example, a particular differentiating marker, CD14 antigen, is not found in dendritic cells but is possessed by monocytes. Also, mature dendritic cells are not phagocytic, whereas the monocytes are strongly phagocytosing cells. It has been shown that DCs provide all the signals necessary for T cell activation and proliferation.

The term "antigen presenting cell recruitment factors" or "APC recruitment factors" include both intact, whole cells as well as other molecules that are capable of recruiting antigen presenting cells. Examples of suitable APC recruitment factors include molecules such as interleukin 4 (IL-4), granulocyte macrophage colony stimulating factor (GM-CSF), Sepragel and macrophage inflammatory protein-3-alpha (MIP3α). These are available from Immunex, Schering-Plough and R&D Systems (Minneapolis, MN). They also can be recombinantly produced using the methods disclosed in CURRENT PROTOCOLS IN MOLECULAR BIOLOGY (F.M. Ausubel et al., eds. (1987)). Peptides, proteins and compounds having the same biological activity as the above-noted factors are included within the scope of this invention.

The term "immune effector cells" refers to cells capable of binding an antigen and which mediate an immune response. These cells include, but are not limited to, T cells, B cells, monocytes, macrophages, NK cells and cytotoxic T lymphocytes (CTLs), for example CTL lines, CTL clones, and CTLs from tumor, inflammatory, or other infiltrates. Certain diseased tissue expresses specific antigens and CTLs specific for these antigens have been identified. For example, approximately 80% of melanomas express the antigen known as gp-100.

The term "immune effector molecule" as used herein, refers to molecules capable of antigen-specific binding, and includes antibodies, T cell antigen receptors, and MHC Class I and Class II molecules.

A "naïve" immune effector cell is an immune effector cell that has never been exposed to an antigen capable of activating that cell. Activation of naïve immune effector cells requires both recognition of the peptide:MHC complex and the simultaneous delivery

of a costimulatory signal by a professional APC in order to proliferate and differentiate into antigen-specific armed effector T cells.

"Immune response" broadly refers to the antigen-specific responses of lymphocytes to foreign substances. Any substance that can elicit an immune response is said to be "immunogenic" and is referred to as an "immunogen". All immunogens are antigens, however, not all antigens are immunogenic. An immune response of this invention can be humoral (via antibody activity) or cell-mediated (via T cell activation).

The term "ligand" as used herein refers to any molecule that binds to a specific site on another molecule. In other words, the ligand confers the specificity of the protein in a reaction with an immune effector cell. It is the ligand site within the protein that combines directly with the complementary binding site on the immune effector cell.

In one embodiment, a ligand of the invention binds to an antigenic determinant or epitope on an immune effector cell, such as an antibody or a T cell receptor (TCR). A ligand may be an antigen, peptide, protein or epitope of the invention.

Invention ligands may bind to a receptor on an antibody. In one embodiment, the ligand of the invention is about 4 to about 8 amino acids in length.

Invention ligands may bind to a receptor on an MHC class I molecule. In one embodiment, the ligand of the invention is about 7 to about 11 amino acids in length.

Invention ligands may bind to a receptor on an MHC class II molecule. In one embodiment, the ligand of the invention is about 10 to about 20 amino acids long.

As used herein, the term "educated, antigen-specific immune effector cell", is an immune effector cell as defined above, which has previously encountered an antigen. In contrast with its naïve counterpart, activation of an educated, antigen-specific immune effector cell does not require a costimulatory signal. Recognition of the peptide:MHC complex is sufficient.

"Activated", when used in reference to a T cell, implies that the cell is no longer in G_0 phase, and begins to produce one or more of cytotoxins, cytokines, and other related membrane-associated proteins characteristic of the cell type (*e.g.*, $CD8^+$ or $CD4^+$), is capable of recognizing and binding any target cell that displays the particular antigen on its surface, and releasing its effector molecules.

In the context of the present invention, the term "recognized" intends that a composition of the invention, comprising one or more ligands, is recognized and bound by an immune effector cell wherein such binding initiates an effective immune response.

Assays for determining whether a ligand is recognized by an immune effector cell are known in the art and are described herein.

The term "preferentially recognized" intends that the specificity of a composition or ligand of the invention is restricted to immune effector cells that recognize and bind the native ligand.

The term "cross-reactive" is used to describe certain immunogenic properties of invention compounds which are functionally overlapping. More particularly, the immunogenic properties of a native ligand and/or immune effector cells activated thereby are shared to a certain extent by the altered ligand such that the altered ligand is "cross-reactive" with the native ligand and/or the immune effector cells activated thereby. For purposes of this invention, cross-reactivity is manifested at multiple levels: (i) at the ligand level, *e.g.,* the altered ligands can bind the TCR of and activate native ligand CTLs; (ii) at the T cell level, *i.e.,* altered ligands of the invention bind the TCR of and activate a population of T cells (distinct from the population of native ligand CTLs) which can effectively target and lyse cells displaying the native ligand; and (iii) at the antibody level, *e.g.,* "anti"-altered ligand antibodies can detect, recognize and bind the native ligand and initiate effector mechanisms in an immune response which ultimately result in elimination of the native ligand from the host.

As used herein, the term "inducing an immune response in a subject" is a term well understood in the art and intends that an increase of at least about 2-fold, more preferably at least about 5-fold, more preferably at least about 10-fold, more preferably at least about 100-fold, even more preferably at least about 500-fold, even more preferably at least about 1000-fold or more in an immune response to an antigen (or epitope) can be detected or measured, after introducing the antigen (or epitope) into the subject, relative to the immune response (if any) before introduction of the antigen (or epitope) into the subject. An immune response to an antigen (or epitope), includes, but is not limited to, production of an antigen-specific (or epitope-specific) antibody, and production of an immune cell expressing on its surface a molecule which specifically binds to an antigen (or epitope). Methods of determining whether an immune response to a given antigen (or epitope) has been induced are well known in the art. For example, antigen-specific antibody can be detected using any of a variety of immunoassays known in the art, including, but not limited to, ELISA, wherein, for example, binding of an antibody in a sample to an immobilized antigen (or epitope) is detected with a detectably-labeled second antibody (*e.g.*, enzyme-labeled mouse anti-human Ig antibody).

"Co-stimulatory molecules" are involved in the interaction between receptor-ligand pairs expressed on the surface of antigen presenting cells and T cells. Research accumulated over the past several years has demonstrated convincingly that resting T cells require at least two signals for induction of cytokine gene expression and proliferation (Schwartz R.H. (1990) Science **248**:1349-1356 and Jenkins M.K. (1992) Immunol. Today **13**:69-73). One signal, the one that confers specificity, can be produced by interaction of the TCR/CD3 complex with an appropriate MHC/peptide complex. The second signal is not antigen specific and is termed the "co-stimulatory" signal. This signal was originally defined as an activity provided by bone-marrow-derived accessory cells such as macrophages and dendritic cells, the so called "professional" APCs. Several molecules have been shown to enhance co-stimulatory activity. These are heat stable antigen (HSA) (Liu Y. et al. (1992) J. Exp. Med. **175**:437-445), chondroitin sulfate-modified MHC invariant chain (Ii-CS) (Naujokas M.F. et al. (1993) Cell **74**:257-268), intracellular adhesion molecule 1 (ICAM-1) (Van Seventer G.A. (1990) J. Immunol. **144**:4579-4586), B7-1, and B7-2/B70 (Schwartz R.H. (1992) Cell **71**:1065-1068). These molecules each appear to assist co-stimulation by interacting with their cognate ligands on the T cells. Co-stimulatory molecules mediate co-stimulatory signal(s), which are necessary, under normal physiological conditions, to achieve full activation of naïve T cells. One exemplary receptor-ligand pair is the B7 co-stimulatory molecule on the surface of APCs and its counter-receptor CD28 or CTLA-4 on T cells (Freeman et al. (1993) Science **262**:909-911; Young et al. (1992) J. Clin. Invest. **90**:229 and Nabavi et al. (1992) Nature **360**:266-268). Other important co-stimulatory molecules are CD40, CD54, CD80, and CD86. The term "co-stimulatory molecule" encompasses any single molecule or combination of molecules which, when acting together with a peptide/MHC complex bound by a TCR on the surface of a T cell, provides a co-stimulatory effect which achieves activation of the T cell that binds the peptide. The term thus encompasses B7, or other co-stimulatory molecule(s) on an antigen-presenting matrix such as an APC, fragments thereof (alone, complexed with another molecule(s), or as part of a fusion protein) which, together with peptide/MHC complex, binds to a cognate ligand and results in activation of the T cell when the TCR on the surface of the T cell specifically binds the peptide. Co-stimulatory molecules are commercially available from a variety of sources, including, for example, Beckman Coulter, Inc. (Fullerton, CA). It is intended, although not always explicitly stated, that molecules having similar biological activity as wild-type or purified co-stimulatory molecules (*e.g.*,

recombinantly produced or muteins thereof) are intended to be used within the spirit and scope of the invention.

As used herein, "solid phase support" or "solid support", used interchangeably, is not limited to a specific type of support. Rather a large number of supports are available and are known to one of ordinary skill in the art. Solid phase supports include silica gels, resins, derivatized plastic films, glass beads, glass slides, flasks, tissue culture flasks, cotton, plastic beads, alumina gels. As used herein, "solid support" also includes synthetic antigen-presenting matrices, cells, and liposomes. A suitable solid phase support may be selected on the basis of desired end use and suitability for various protocols. For example, for peptide synthesis, solid phase support may refer to resins such as polystyrene (*e.g.*, PAM-resin obtained from Bachem Inc., Peninsula Laboratories, etc.), POLYHIPE® resin (obtained from Aminotech, Canada), polyamide resin (obtained from Peninsula Laboratories), polystyrene resin grafted with polyethylene glycol (TentaGel®, Rapp Polymere, Tubingen, Germany) or polydimethylacrylamide resin (obtained from Milligen/Biosearch, California). Solid supports also include microchips and grids, on which cDNAs, oligonucleotides, peptides, antibodies or other molecules are fixed in arrays. The surface of the grids may be composed of a wide variety of material including glass, plastic, silicon, gold, gelatin or nylon. Lockhart (2000) Nature, 405:827-836; Srinivas (2001) Clin. Chem., **47**:1901-1911, and further described herein.

The components and compositions for use in the methods of this invention can also provided on microchips. For example, the use of the so-called SELDI-MS method (Surface-Enhanced Laser Desorption-Ionization & Mass Spectroscopy) exposes samples to chips with biochemically characterized surfaces (containing molecules such as antibodies or receptors) followed by mass spectroscopy to visualize and identify the bound proteins. For a review of recently available technology see Srivinas P, et al. (2001) Clinical Chemistry **47**(10):1901-1911, and references cited therein such as De Wildt, RMT et al. (2000) Nat. Biotech **18**:989-94, Arenkov, P et al. (2000) Anal. Biochem. **278**:123-31, Haab, BB et al.(2001) Genome Biol. **2**:1-13, and Cahill, DJ. (2001) J Immunol. Methods **250**:81-91. Also included within a solid support are tissue microarrays in which small cylinders of tissue are punched out of thousands of individual tumor specimens (from different tissues of hundreds of individuals in a study) and then probed with antibodies, RNA, etc. Hoos A, et al. (2001) Am J. Pathol. **158**:1245-51.

The term "immunomodulatory agent", as used herein, is a molecule, a macromolecular complex, or a cell that modulates an immune response and encompasses an antigenic peptide of the invention alone or in any of a variety of formulations described herein; a polypeptide comprising an antigenic peptide of the invention; a polynucleotide encoding a peptide or polypeptide of the invention; an antigenic peptide of the invention bound to a Class I or a Class II MHC molecule on an antigen-presenting matrix, including an APC and a synthetic antigen-presenting matrix (in the presence or absence of co-stimulatory molecule(s)); an antigenic peptide of the invention covalently or non-covalently complexed to another molecule(s) or macromolecular structure; and an educated, antigen-specific immune effector cell which is specific for a peptide of the invention.

The term "modulate an immune response" includes inducing (increasing, eliciting) an immune response; and reducing (suppressing) an immune response. An immunomodulatory method (or protocol) is one that modulates an immune response in a subject.

As used herein, the term "cytokine" refers to any one of the numerous factors that exert a variety of effects on cells, for example, inducing growth or proliferation. Non-limiting examples of cytokines which may be used alone or in combination in the practice of the present invention include, interleukin-2 (IL-2), stem cell factor (SCF), interleukin 3 (IL-3), interleukin 6 (IL-6), interleukin 12 (IL-12), G-CSF, granulocyte macrophage-colony stimulating factor (GM-CSF), interleukin-1 alpha (IL-1α), interleukin-11 (IL-11), MIP-11, leukemia inhibitory factor (LIF), c-kit ligand, thrombopoietin (TPO) and flt3 ligand. The present invention also includes culture conditions in which one or more cytokine is specifically excluded from the medium. Cytokines are commercially available from several vendors such as, for example, Genzyme (Framingham, MA), Genentech (South San Francisco, CA), Amgen (Thousand Oaks, CA), R&D Systems (Minneapolis, MN) and Immunex (Seattle, WA). It is intended, although not always explicitly stated, that molecules having similar biological activity as wild-type or purified cytokines (*e.g.*, recombinantly produced or muteins thereof) are intended to be used within the spirit and scope of the invention.

The terms "polynucleotide" and "nucleic acid molecule" are used interchangeably to refer to polymeric forms of nucleotides of any length. The polynucleotides may contain deoxyribonucleotides, ribonucleotides, and/or their analogs. Nucleotides may have any three-dimensional structure, and may perform any function, known or unknown. The term "polynucleotide" includes, for example, single-stranded, double-stranded and triple helical

molecules, a gene or gene fragment, exons, introns, mRNA, tRNA, rRNA, ribozymes, cDNA, recombinant polynucleotides, branched polynucleotides, plasmids, vectors, isolated DNA of any sequence, isolated RNA of any sequence, nucleic acid probes, and primers. In addition to a native nucleic acid molecule, a nucleic acid molecule of the present invention may also comprise modified nucleic acid molecules.

The term "peptide" is used in its broadest sense to refer to a compound of two or more subunit amino acids, amino acid analogs, or peptidomimetics. The subunits may be linked by peptide bonds. In another embodiment, the subunit may be linked by other bonds, *e.g.* ester, ether, etc. As used herein the term "amino acid" refers to either natural and/or unnatural or synthetic amino acids, including glycine and both the D or L optical isomers, and amino acid analogs and peptidomimetics. A peptide of three or more amino acids is commonly called an oligopeptide if the peptide chain is short. If the peptide chain is long, the peptide is commonly called a polypeptide or a protein.

The term "genetically modified" means containing and/or expressing a foreign gene or nucleic acid sequence which in turn, modifies the genotype or phenotype of the cell or its progeny. In other words, it refers to any addition, deletion or disruption to a cell's endogenous nucleotides.

As used herein, "expression" refers to the process by which polynucleotides are transcribed into mRNA and translated into peptides, polypeptides, or proteins. If the polynucleotide is derived from genomic DNA, expression may include splicing of the mRNA, if an appropriate eukaryotic host is selected. Regulatory elements required for expression include promoter sequences to bind RNA polymerase and transcription initiation sequences for ribosome binding. For example, a bacterial expression vector includes a promoter such as the *lac* promoter and for transcription initiation the Shine-Dalgarno sequence and the start codon AUG (Sambrook et al. (1989) *supra*). Similarly, an eukaryotic expression vector includes a heterologous or homologous promoter for RNA polymerase II, a downstream polyadenylation signal, the start codon AUG, and a termination codon for detachment of the ribosome. Such vectors can be obtained commercially or assembled by the sequences described in methods well known in the art, for example, the methods described below for constructing vectors in general.

"Under transcriptional control" is a term well understood in the art and indicates that transcription of a polynucleotide sequence, usually a DNA sequence, depends on its being operatively linked to an element which contributes to the initiation of, or promotes,

transcription. "Operatively linked" refers to a juxtaposition wherein the elements are in an arrangement allowing them to function.

A "gene delivery vehicle" is defined as any molecule that can carry inserted polynucleotides into a host cell. Examples of gene delivery vehicles are liposomes, biocompatible polymers, including natural polymers and synthetic polymers; lipoproteins; polypeptides; polysaccharides; lipopolysaccharides; artificial viral envelopes; metal particles; and bacteria, or viruses, such as baculovirus, adenovirus and retrovirus, bacteriophage, cosmid, plasmid, fungal vectors and other recombination vehicles typically used in the art which have been described for expression in a variety of eukaryotic and prokaryotic hosts, and may be used for gene therapy as well as for simple protein expression.

"Gene delivery," "gene transfer," and the like as used herein, are terms referring to the introduction of an exogenous polynucleotide (sometimes referred to as a "transgene") into a host cell, irrespective of the method used for the introduction. Such methods include a variety of well-known techniques such as vector-mediated gene transfer (by, *e.g.*, viral infection/transfection, or various other protein-based or lipid-based gene delivery complexes) as well as techniques facilitating the delivery of "naked" polynucleotides (such as electroporation, "gene gun" delivery and various other techniques used for the introduction of polynucleotides). The introduced polynucleotide may be stably or transiently maintained in the host cell. Stable maintenance typically requires that the introduced polynucleotide either contains an origin of replication compatible with the host cell or integrates into a replicon of the host cell such as an extrachromosomal replicon (*e.g.*, a plasmid) or a nuclear or mitochondrial chromosome. A number of vectors are known to be capable of mediating transfer of genes to mammalian cells, as is known in the art and described herein.

A "viral vector" is defined as a recombinantly produced virus or viral particle that comprises a polynucleotide to be delivered into a host cell, either *in vivo*, *ex vivo* or *in vitro*. Examples of viral vectors include retroviral vectors, adenovirus vectors, adeno-associated virus vectors, alphavirus vectors and the like. Alphavirus vectors, such as Semliki Forest virus-based vectors and Sindbis virus-based vectors, have also been developed for use in gene therapy and immunotherapy. See, Schlesinger and Dubensky (1999) Curr Opin Biotechnol. **5**:434-439 and Zaks et al. (1999) Nat. Med. **7**:823-827. In aspects where gene transfer is mediated by a retroviral vector, a vector construct refers to the polynucleotide comprising the retroviral genome or part thereof, and a therapeutic gene. As used herein,

"retroviral mediated gene transfer" or "retroviral transduction" carries the same meaning and refers to the process by which a gene or nucleic acid sequences are stably transferred into the host cell by virtue of the virus entering the cell and integrating its genome into the host cell genome. The virus can enter the host cell via its normal mechanism of infection or be modified such that it binds to a different host cell surface receptor or ligand to enter the cell. As used herein, retroviral vector refers to a viral particle capable of introducing exogenous nucleic acid into a cell through a viral or viral-like entry mechanism.

Retroviruses carry their genetic information in the form of RNA; however, once the virus infects a cell, the RNA is reverse-transcribed into the DNA form which integrates into the genomic DNA of the infected cell. The integrated DNA form is called a provirus.

In aspects where gene transfer is mediated by a DNA viral vector, such as an adenovirus (Ad) or adeno-associated virus (AAV), a vector construct refers to the polynucleotide comprising the viral genome or part thereof, and a transgene. Adenoviruses (Ads) are a relatively well characterized, homogenous group of viruses, including over 50 serotypes. See, *e.g.*, WO 95/27071. Ads are easy to grow and do not require integration into the host cell genome. Recombinant Ad-derived vectors, particularly those that reduce the potential for recombination and generation of wild-type virus, have also been constructed. See, WO 95/00655 and WO 95/11984. Wild-type AAV has high infectivity and specificity integrating into the host cell's genome. See, Hermonat and Muzyczka (1984) Proc. Natl. Acad. Sci. USA **81**:6466-6470 and Lebkowski et al. (1988) Mol. Cell. Biol. **8**:3988-3996.

Vectors that contain both a promoter and a cloning site into which a polynucleotide can be operatively linked are well known in the art. Such vectors are capable of transcribing RNA *in vitro* or *in vivo*, and are commercially available from sources such as Stratagene (La Jolla, CA) and Promega Biotech (Madison, WI). In order to optimize expression and/or *in vitro* transcription, it may be necessary to remove, add or alter 5' and/or 3' untranslated portions of the clones to eliminate extra, potential inappropriate alternative translation initiation codons or other sequences that may interfere with or reduce expression, either at the level of transcription or translation. Alternatively, consensus ribosome binding sites can be inserted immediately 5' of the start codon to enhance expression.

Gene delivery vehicles also include several non-viral vectors, including DNA/liposome complexes, and targeted viral protein-DNA complexes. Liposomes that also comprise a targeting antibody or fragment thereof can be used in the methods of this invention. To enhance delivery to a cell, the nucleic acid or proteins of this invention can

be conjugated to antibodies or binding fragments thereof which bind cell surface antigens, *e.g.*, TCR, CD3 or CD4.

"Hybridization" refers to a reaction in which one or more polynucleotides react to form a complex that is stabilized via hydrogen bonding between the bases of the nucleotide residues. The hydrogen bonding may occur by Watson-Crick base pairing, Hoogstein binding, or in any other sequence-specific manner. The complex may comprise two strands forming a duplex structure, three or more strands forming a multi-stranded complex, a single self-hybridizing strand, or any combination of these. A hybridization reaction may constitute a step in a more extensive process, such as the initiation of a PCR reaction, or the enzymatic cleavage of a polynucleotide by a ribozyme.

Examples of stringent hybridization conditions include: incubation temperatures of about 25°C to about 37°C; hybridization buffer concentrations of about 6 X SSC to about 10 X SSC; formamide concentrations of about 0% to about 25%; and wash solutions of about 6 X SSC. Examples of moderate hybridization conditions include: incubation temperatures of about 40°C to about 50°C; buffer concentrations of about 9 X SSC to about 2 X SSC; formamide concentrations of about 30% to about 50%; and wash solutions of about 5 X SSC to about 2 X SSC. Examples of high stringency conditions include: incubation temperatures of about 55°C to about 68°C; buffer concentrations of about 1 X SSC to about 0.1 X SSC; formamide concentrations of about 55% to about 75%; and wash solutions of about 1 X SSC, 0.1 X SSC, or deionized water. In general, hybridization incubation times are from 5 minutes to 24 hours, with 1, 2, or more washing steps, and wash incubation times are about 1, 2, or 15 minutes. SSC is 0.15 M NaCl and 15 mM citrate buffer. It is understood that equivalents of SSC using other buffer systems can be employed.

A polynucleotide or polynucleotide region (or a polypeptide or polypeptide region) has a certain percentage (for example, 80%, 85%, 90%, or 95%) of "sequence identity" to another sequence means that, when aligned, that percentage of bases (or amino acids) are the same in comparing the two sequences. This alignment and the percent homology or sequence identity can be determined using software programs known in the art, for example those described in CURRENT PROTOCOLS IN MOLECULAR BIOLOGY (F.M. Ausubel et al., eds., 1987) Supplement 30, section 7.7.18, Table 7.7.1. Preferably, default parameters are used for alignment. A preferred alignment program is BLAST, using default parameters. In particular, preferred programs are BLASTN and BLASTP, using the following default parameters: Genetic code = standard; filter = none; strand = both; cutoff = 60; expect = 10;

Matrix = BLOSUM62; Descriptions = 50 sequences; sort by = HIGH SCORE; Databases = non-redundant, GenBank + EMBL + DDBJ + PDB + GenBank CDS translations + SwissProtein + SPupdate + PIR. Details of these programs can be found at the following Internet address: http://www.ncbi.nlm.nih.gov/cgi-bin/BLAST.

"*In vivo*" gene delivery, gene transfer, gene therapy and the like as used herein, are terms referring to the introduction of a vector comprising an exogenous polynucleotide directly into the body of an organism, such as a human or non-human mammal, whereby the exogenous polynucleotide is introduced to a cell of such organism *in vivo*.

The term "isolated" means separated from constituents, cellular and otherwise, in which the polynucleotide, peptide, polypeptide, protein, antibody, or fragments thereof, are normally associated with in nature. For example, with respect to a polynucleotide, an isolated polynucleotide is one that is separated from the 5' and 3' sequences with which it is normally associated in the chromosome. As is apparent to those of skill in the art, a non-naturally occurring polynucleotide, peptide, polypeptide, protein, antibody, or fragments thereof, does not require "isolation" to distinguish it from its naturally occurring counterpart. In addition, a "concentrated", "separated" or "diluted" polynucleotide, peptide, polypeptide, protein, antibody, or fragments thereof, is distinguishable from its naturally occurring counterpart in that the concentration or number of molecules per volume is greater than "concentrated" or less than "separated" than that of its naturally occurring counterpart. A polynucleotide, peptide, polypeptide, protein, antibody, or fragments thereof, which differs from the naturally occurring counterpart in its primary sequence or for example, by its glycosylation pattern, need not be present in its isolated form since it is distinguishable from its naturally occurring counterpart by its primary sequence, or alternatively, by another characteristic such as glycosylation pattern. Although not explicitly stated for each of the inventions disclosed herein, it is to be understood that all of the above embodiments for each of the compositions disclosed below and under the appropriate conditions, are provided by this invention. Thus, a non-naturally occurring polynucleotide is provided as a separate embodiment from the isolated naturally occurring polynucleotide. A protein produced in a bacterial cell is provided as a separate embodiment from the naturally occurring protein isolated from a eukaryotic cell in which it is produced in nature.

"Host cell," "target cell" or "recipient cell" are intended to include any individual cell or cell culture which can be or have been recipients for vectors or the incorporation of exogenous nucleic acid molecules, polynucleotides and/or proteins. It also is intended to

include progeny of a single cell, and the progeny may not necessarily be completely identical (in morphology or in genomic or total DNA complement) to the original parent cell due to natural, accidental, or deliberate mutation. The cells may be prokaryotic or eukaryotic, and include but are not limited to bacterial cells, yeast cells, animal cells, and mammalian cells, *e.g.*, murine, rat, simian or human.

A "subject" is a vertebrate, preferably a mammal, more preferably a human. Mammals include, but are not limited to, murines, simians, humans, farm animals, sport animals, and pets.

A "control" is an alternative subject or sample used in an experiment for comparison purpose. A control can be "positive" or "negative". For example, where the purpose of the experiment is to determine a correlation of an altered expression level of a gene with a particular type of cancer, it is generally preferable to use a positive control (a subject or a sample from a subject, carrying such alteration and exhibiting syndromes characteristic of that disease), and a negative control (a subject or a sample from a subject lacking the altered expression and clinical syndrome of that disease).

The terms "cancer," "neoplasm," and "tumor," used interchangeably and in either the singular or plural form, refer to cells that have undergone a malignant transformation that makes them pathological to the host organism. Primary cancer cells (that is, cells obtained from near the site of malignant transformation) can be readily distinguished from non-cancerous cells by well-established techniques, particularly histological examination. The definition of a cancer cell, as used herein, includes not only a primary cancer cell, but also any cell derived from a cancer cell ancestor. This includes metastasized cancer cells, and *in vitro* cultures and cell lines derived from cancer cells. When referring to a type of cancer that normally manifests as a solid tumor, a "clinically detectable" tumor is one that is detectable on the basis of tumor mass; *e.g.*, by such procedures as CAT scan, magnetic resonance imaging (MRI), X-ray, ultrasound or palpation. Biochemical or immunologic findings alone may be insufficient to meet this definition.

A neoplasm is an abnormal mass or colony of cells produced by a relatively autonomous new growth of tissue. Most neoplasms arise from the clonal expansion of a single cell that has undergone neoplastic transformation. The transformation of a normal to a neoplastic cell can be caused by a chemical, physical, or biological agent (or event) that directly and irreversibly alters the cell genome. Neoplastic cells are characterized by the loss of some specialized functions and the acquisition of new biological properties,

foremost, the property of relatively autonomous (uncontrolled) growth. Neoplastic cells pass on their heritable biological characteristics to progeny cells.

The past, present, and future predicted biological behavior, or clinical course, of a neoplasm is further classified as benign or malignant, a distinction of great importance in diagnosis, treatment, and prognosis. A malignant neoplasm manifests a greater degree of autonomy, is capable of invasion and metastatic spread, may be resistant to treatment, and may cause death. A benign neoplasm has a lesser degree of autonomy, is usually not invasive, does not metastasize, and generally produces no great harm if treated adequately.

Cancer is a generic term for malignant neoplasms. Anaplasia is a characteristic property of cancer cells and denotes a lack of normal structural and functional characteristics (undifferentiation).

A tumor is literally a swelling of any type, such as an inflammatory or other swelling, but modern usage generally denotes a neoplasm. The suffix "-oma" means tumor and usually denotes a benign neoplasm, as in fibroma, lipoma, and so forth, but sometimes implies a malignant neoplasm, as with so-called melanoma, hepatoma, and seminoma, or even a non-neoplastic lesion, such as a hematoma, granuloma, or hamartoma.

The suffix "-blastoma" denotes a neoplasm of embryonic cells, such as neuroblastoma of the adrenal or retinoblastoma of the eye.

Histogenesis is the origin of a tissue and is a method of classifying neoplasms on the basis of the tissue cell of origin. Adenomas are benign neoplasms of glandular epithelium. Carcinomas are malignant tumors of epithelium. Sarcomas are malignant tumors of mesenchymal tissues.

One system to classify neoplasia utilizes biological (clinical) behavior, whether benign or malignant, and the histogenesis, the tissue or cell of origin of the neoplasm as determined by histologic and cytologic examination. Neoplasms may originate in almost any tissue containing cells capable of mitotic division. The histogenetic classification of neoplasms is based upon the tissue (or cell) of origin as determined by histologic and cytologic examination.

"Suppressing" tumor growth indicates a growth state that is curtailed compared to growth without contact with educated, antigen-specific immune effector cells described herein. Tumor cell growth can be assessed by any means known in the art, including, but not limited to, measuring tumor size, determining whether tumor cells are proliferating using a ^{3}H-thymidine incorporation assay, or counting tumor cells. "Suppressing" tumor cell growth means any or all of the following states: slowing, delaying, and "suppressing"

tumor growth indicates a growth state that is curtailed when stopping tumor growth, as well as tumor shrinkage.

The term "culturing" refers to the *in vitro* propagation of cells or organisms on or in media of various kinds. It is understood that the descendants of a cell grown in culture may not be completely identical (morphologically, genetically, or phenotypically) to the parent cell. By "expanded" is meant any proliferation or division of cells.

A "composition" is intended to mean a combination of active agent and another compound or composition, inert (for example, a detectable agent or label) or active, such as an adjuvant.

A "pharmaceutical composition" is intended to include the combination of an active agent with a carrier, inert or active, making the composition suitable for diagnostic or therapeutic use *in vitro*, *in vivo* or *ex vivo*.

As used herein, the term "pharmaceutically acceptable carrier" encompasses any of the standard pharmaceutical carriers, such as a phosphate buffered saline solution, water, and emulsions, such as an oil/water or water/oil emulsion, and various types of wetting agents. The compositions also can include stabilizers and preservatives. For examples of carriers, stabilizers and adjuvants, see Martin REMINGTON'S PHARM. SCI., 15th Ed. (Mack Publ. Co., Easton (1975)).

An "effective amount" is an amount sufficient to effect beneficial or desired results. An effective amount can be administered in one or more administrations, applications or dosages.

This invention relates to the identification of novel immunogenic factors. In a first aspect, this invention provides an isolated amino acid sequence for a novel native human Brain Type Glycogen Phosphorylase ("BGP") ligand. This native human BGP ligand was not known or appreciated, prior to this invention, to having immunogenic properties relevant to human colon cancer. Compositions which include the novel native human BGP ligand and methods for the use of such sequences are contemplated herein.

The present invention also provides compositions that bind to MHC molecules and are useful for modulating immune responses to the cognate native antigenic epitopes and their corresponding native proteins.

This invention further provides compositions which are useful as components of anti-cancer vaccines and to expand immune effector cells that are specific for cells characterized by differential, i.e., aberrant, expression of antigen BGP.

A "BGP- related cancer or malignancy" is one in which the differential expression of the antigenic protein serves as a marker for the neoplastic phenotype. An example of a cancer type exhibiting differential expression of the BGP antigen includes, but is not limited to, colon cancer.

In one embodiment, the altered ligands of the invention have comparable or enhanced affinity for MHC binding to the native antigenic epitope. It has been demonstrated that peptide:MHC class I binding properties correlate with immunogenicity (Sette A. et al. (1994) Immunol. **153**:5586; van der Burg S.H. et al. (1996) J. Immunol. **156**:3308). Comparative binding of the ligands of the invention to an MHC class I molecule can be measured by methods that are known in the art and include, but are not limited to, calculating the affinity based on an algorithm (see, for example, Parker et al. (1992) J. Immunol. **149**:3580-3587) and experimentally determining binding affinity (see, for example, Tan et al. (1997) J. Immunol. Meth. **209**(1):25-36). For example, the relative binding of a peptide to a class I molecule can be measured on the basis of binding of a radiolabeled standard peptide to detergent-solubilized MHC molecules, using various concentrations of test peptides (*e.g.*, ranging from 100 mM to 1nM). MHC class I heavy chain and β_2-microglobulin are coincubated with a fixed concentration (*e.g.*, 5 nM) radiolabeled standard (control) peptide and various concentrations of a test peptide for a suitable period of time (*e.g.*, 2 hours to 72 hours) at room temperature in the presence of a mixture of protease inhibitors. A control tube contains standard peptide and MHC molecules, but no test peptide. The percent MHC-bound radioactivity is determined by gel filtration. The IC_{50} (concentration of test peptide which results in 50% inhibition of binding of control peptide) is calculated for each peptide. Additional methods for determining binding affinity are known in the art. In another embodiment, the ligands of the invention elicit comparable or enhanced antigen-specific T cell activation to the native antigenic epitope. Methods for determining immunogenicity of invention ligands are known in the art and include, but are not limited to, those described in al-Ramadi et al. (1992) J. Immunol. **155**(2):662-673; and Zuegel et al. (1998) J. Immunol. **161**(4):1705-1709.

The present invention provides novel ligands, compounds and related compositions for therapeutic, prophylactic and diagnostic use. In a first aspect, this invention provides a novel ligand and corresponding protein, neither of which were heretofore known to be associated with lung cancer. The gene BGP, (GenBank Accession No. J03544) which encodes the native protein and ligand is also identified herein. In a different aspect, this

invention provides novel compounds *i.e.*, altered ligands that are "cross-reactive" with the native ligand.

The native and the altered ligands of the invention are useful in therapeutic, prophylactic, and diagnostic applications.

urther provided are polynucleotides encoding the ligands of the invention, gene delivery vehicles comprising these polynucleotides and host cells comprising these polynucleotides.

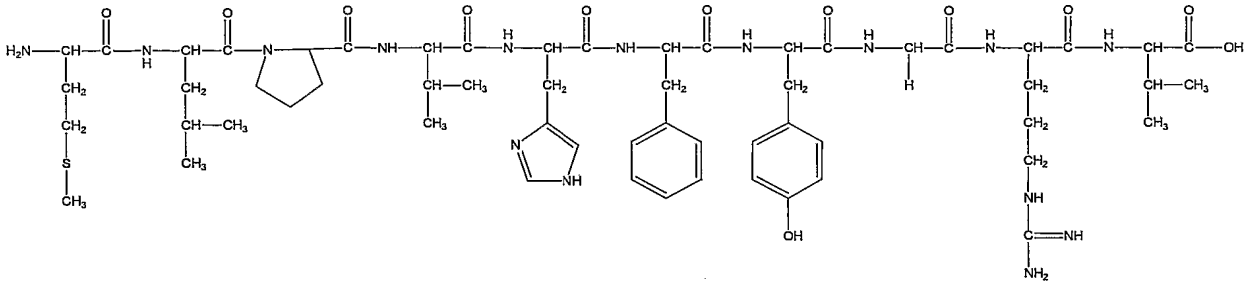
In addition, the invention provides methods for inducing an immune response in a subject by delivering to the subject the ligands of the invention in the context of an MHC molecule.

The ligands of the invention are also useful as immunogens to generate antibodies that specifically recognize and bind to these ligands. The ligands of the invention can also be used in recombinant methods to construct antibodies that specifically recognize and bind to these ligands. The antibodies so generated are further useful in therapeutic and diagnostic applications.

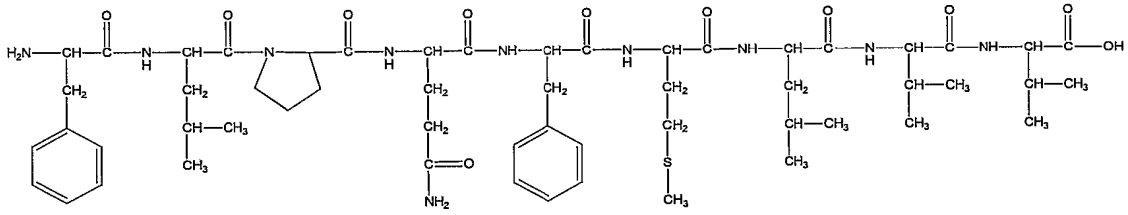
The invention further provides immune effector cells raised *in vivo* or *in vitro* in the presence and at the expense of an antigen presenting cell (APC) that presents the native or altered ligand compositions of the invention in the context of an MHC molecule and a method of adoptive immunotherapy comprising administering an effective amount of these immune effector cells to a subject.

The present invention provides compounds having the following structure:

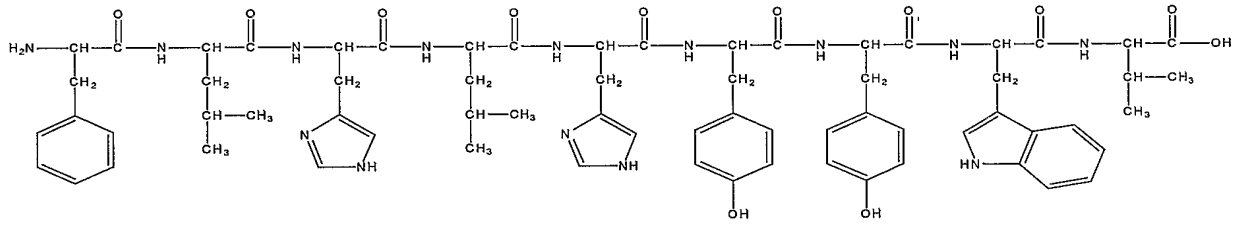
MLPVHFYGRV



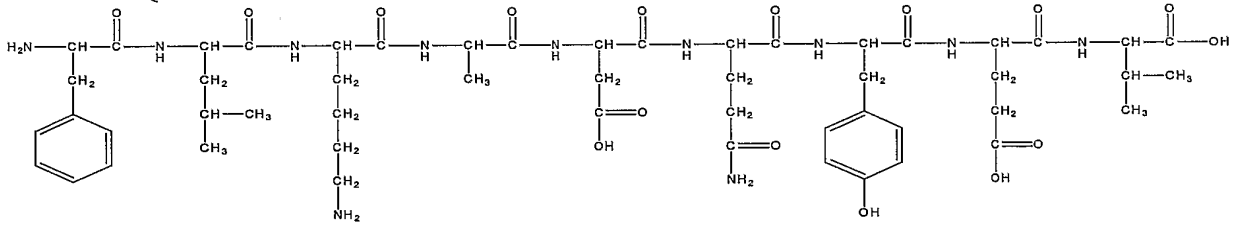
FLPQFMLVV



FLHLHYYWV



FLKADQYEV



The present invention also provides compositions that exhibit enhancing binding to MHC molecules and are cross-reactive with and useful for modulating immune responses to the cognate native ligands and their corresponding native proteins.

This invention further provides compositions which are useful as components of anti-cancer vaccines and to expand immune effector cells that are specific for cancers characterized by expression of BGP

In one embodiment, compositions of the invention comprise at least one, immunogenic ligand of the invention. In one aspect, such compositions may comprise at least one, or alternatively, two or more copies of a single ligand. In another aspect, such compositions may comprise two or more ligands, wherein each ligand of said two or more ligands is distinct from all other ligands in said composition. In one embodiment, the two or more immunogenic ligands are covalently linked.

This invention provides novel, antigenic peptide sequences, which are useful as components of anti-cancer vaccines and to expand immune effector cells that are specific for cells and cancer cells characterized by differential expression of the human cancer antigenic BGP.

Further encompassed by the term "antigenic peptide" are multimers (concatemers) of an antigenic peptide of the invention, optionally including intervening amino acid sequences as well as polypeptides comprising the sequences of SEQ ID NOs. 2, 3, 5, 7, and 9. The invention also provides polypeptides comprising these sequences wherein the polypeptides are preferentially recognized by human cancer antigen BGP cytotoxic T lymphocytes.

Polypeptides comprising the peptide sequences of the invention can be prepared by altering the sequence of polynucleotides that encode the native human antigen BGP polypeptide sequence. This is accomplished by methods of recombinant DNA technology well know to those skilled in the art. For example, site directed mutagenesis may be performed on recombinant polynucleotides encoding the native human cancer antigen BGP sequence to introduce changes in the polynucleotide sequence.

The proteins and polypeptides of this invention can be obtained by chemical synthesis using a commercially available automated peptide synthesizer such as those manufactured by Perkin Elmer/Applied Biosystems, Inc., Model 430A or 431A, Foster City, CA, USA. The synthesized protein or polypeptide can be precipitated and further purified, for example by high performance liquid chromatography (HPLC). Accordingly, this invention also provides a process for chemically synthesizing the proteins of this invention by providing the sequence of the protein and reagents, such as amino acids and enzymes and linking together the amino acids in the proper orientation and linear sequence.

Alternatively, the proteins and polypeptides can be obtained by well-known recombinant methods as described herein using the host cell and vector systems described below.

PEPTIDE ANALOGUES

It is well know to those skilled in the art that modifications can be made to the peptides of the invention to provide them with altered properties. As used herein the term "amino acid" refers to either natural and/or unnatural or synthetic amino acids, including glycine and both the D or L optical isomers, and amino acid analogs and peptidomimetics. A peptide of three or more amino acids is commonly called an oligopeptide if the peptide chain is short. If the peptide chain is long, the peptide is commonly called a polypeptide or a protein.

Peptides of the invention can be modified to include unnatural amino acids. Thus, the peptides may comprise D-amino acids, a combination of D- and L-amino acids, and various "designer" amino acids (*e.g.*, β-methyl amino acids, C-α-methyl amino acids, and N-α-methyl amino acids, etc.) to convey special properties to peptides. Additionally, by assigning specific amino acids at specific coupling steps, peptides with α-helices β turns, β sheets, γ-turns, and cyclic peptides can be generated. Generally, it is believed that α-helical secondary structure or random secondary structure is preferred.

In a further embodiment, subunits of peptides that confer useful chemical and structural properties will be chosen. For example, peptides comprising D-amino acids will be resistant to L-amino acid-specific proteases *in vivo*. Modified compounds with D-amino acids may be synthesized with the amino acids aligned in reverse order to produce the peptides of the invention as retro-inverso peptides. In addition, the present invention envisions preparing peptides that have better defined structural properties, and the use of peptidomimetics, and peptidomimetic bonds, such as ester bonds, to prepare peptides with novel properties. In another embodiment, a peptide may be generated that incorporates a reduced peptide bond, *i.e.*, R_1-CH_2NH-R_2, where R_1, and R_2 are amino acid residues or sequences. A reduced peptide bond may be introduced as a dipeptide subunit. Such a molecule would be resistant to peptide bond hydrolysis, *e.g.*, protease activity. Such molecules would provide ligands with unique function and activity, such as extended half-lives *in vivo* due to resistance to metabolic breakdown, or protease activity. Furthermore, it is well known that in certain systems constrained peptides show enhanced functional activity (Hruby (1982) Life Sciences **31**:189-199 and Hruby et al. (1990) Biochem J.

268:249-262); the present invention provides a method to produce a constrained peptide that incorporates random sequences at all other positions.

NON-CLASSICAL AMINO ACIDS THAT INDUCE CONFORMATIONAL CONSTRAINTS.

The following non classical amino acids may be incorporated in the peptides of the invention in order to introduce particular conformational motifs: 1,2,3,4-tetrahydroisoquinoline-3-carboxylate (Kazrnierski et al. (1991) J. Am. Chem. Soc. **113**:2275-2283); (2S,3S)-methyl-phenylalanine, (2S,3R)- methyl-phenylalanine, (2R,3S)-methyl-phenylalanine and (2R,3R)-methyl-phenylalanine (Kazmierski and Hruby (1991) Tetrahedron Lett. **32(41):**5769-5772); 2-aminotetrahydronaphthalene-2- carboxylic acid (Landis (1989) Ph.D. Thesis, University of Arizona); hydroxy-1,2,3,4-tetrahydroisoquinoline-3-carboxylate (Miyake et al. (1989) J. Takeda Res. Labs. **43**:53-76) histidine isoquinoline carboxylic acid (Zechel et al. (1991) Int. J. Pep. Protein Res. **38**(2):131-138); and HIC (histidine cyclic urea), (Dharanipragada et al. (1993) Int. J. Pep. Protein Res. **42**(1):68-77) and ((1992) Acta. Cryst., Crystal Struc. Comm. **48(IV):**1239-1241).

The following amino acid analogs and peptidomimetics may be incorporated into a peptide to induce or favor specific secondary structures: LL-Acp (LL-3-amino-2-propenidone-6-carboxylic acid), a β-turn inducing dipeptide analog (Kemp et al. (1985) J. Org. Chem. **50**:5834-5838); β-sheet inducing analogs (Kemp et al. (1988) Tetrahedron Lett. **29**:5081-5082); β-turn inducing analogs (Kemp et al. (1988) Tetrahedron Lett. **29**:5057-5060); α-helix inducing analogs (Kemp et al. (1988) Tetrahedron Lett. **29**:4935-4938); γ-turn inducing analogs (Kemp et al. (1989) J. Org. Chem. **54**:109:115); analogs provided by the following references: Nagai and Sato (1985) Tetrahedron Lett. **26**:647-650; and DiMaio et al. (1989) J. Chem. Soc. Perkin Trans. p. 1687; a Gly-Ala turn analog (Kahn et al. (1989) Tetrahedron Lett. **30**:2317); amide bond isostere (Clones et al. (1988) Tetrahedron Lett. **29**:38S3-38S6); tretrazol (Zabrocki et al. (1988) J. Am. Chem. Soc. **110**:587S-5880); DTC (Samanen et al. (1990) Int. J. Protein Pep. Res. **35**:501:509); and analogs taught in Olson et al. (1990) J. Am. Chem. Sci. **112**:323-333 and Garvey et al. (1990) J. Org. Chem. **56**:436. Conformationally restricted mimetics of beta turns and beta bulges, and peptides containing them, are described in U.S. Patent No. 5,440,013, issued August 8, 1995 to Kahn.

An antigenic peptide epitope of the invention can be used in a variety of formulations, which may vary depending on the intended use.

An antigenic peptide epitope of the invention can be covalently or non-covalently linked (complexed) to various other molecules, the nature of which may vary depending on the particular purpose. For example, a peptide of the invention can be covalently or non-covalently complexed to a macromolecular carrier, including, but not limited to, natural and synthetic polymers, proteins, polysaccharides, polypeptides (amino acids), polyvinyl alcohol, polyvinyl pyrrolidone, and lipids. A peptide can be conjugated to a fatty acid, for introduction into a liposome. U.S. Patent No. 5,837,249. A peptide of the invention can be complexed covalently or non-covalently with a solid support, a variety of which are known in the art. An antigenic peptide epitope of the invention can be associated with an antigen-presenting matrix with or without co-stimulatory molecules, as described in more detail below.

Examples of protein carriers include, but are not limited to, superantigens, serum albumin, tetanus toxoid, ovalbumin, thyroglobulin, myoglobulin, and immunoglobulin.

Peptide-protein carrier polymers may be formed using conventional cross-linking agents such as carbodimides. Examples of carbodimides are 1-cyclohexyl-3-(2-morpholinyl-(4-ethyl) carbodiimide (CMC), 1-ethyl-3-(3-dimethyaminopropyl) carbodiimide (EDC) and 1-ethyl-3-(4-azonia-44-dimethylpentyl) carbodiimide.

Examples of other suitable cross-linking agents are cyanogen bromide, glutaraldehyde and succinic anhydride. In general, any of a number of homo-bifunctional agents including a homo-bifunctional aldehyde, a homo-bifunctional epoxide, a homo-bifunctional imido-ester, a homo-bifunctional N-hydroxysuccinimide ester, a homo-bifunctional maleimide, a homo-bifunctional alkyl halide, a homo-bifunctional pyridyl disulfide, a homo-bifunctional aryl halide, a homo-bifunctional hydrazide, a homo-bifunctional diazonium derivative and a homo-bifunctional photoreactive compound may be used. Also included are hetero-bifunctional compounds, for example, compounds having an amine-reactive and a sulfhydryl-reactive group, compounds with an amine-reactive and a photoreactive group and compounds with a carbonyl-reactive and a sulfhydryl-reactive group.

Specific examples of such homo-bifunctional cross-linking agents include the bifunctional N-hydroxysuccinimide esters dithiobis(succinimidylpropionate), disuccinimidyl suberate, and disuccinimidyl tartarate; the bifunctional imido-esters dimethyl adipimidate, dimethyl pimelimidate, and dimethyl suberimidate; the bifunctional sulfhydryl-

reactive crosslinkers 1,4-di-[3'-(2'-pyridyldithio) propion-amido]butane, bismaleimidohexane, and bis-N-maleimido-1, 8-octane; the bifunctional aryl halides 1,5-difluoro-2,4-dinitrobenzene and 4,4'-difluoro-3,3'-dinitrophenylsulfone; bifunctional photoreactive agents such as bis-[b-(4-azidosalicylamido)ethyl]disulfide; the bifunctional aldehydes formaldehyde, malondialdehyde, succinaldehyde, glutaraldehyde, and adipaldehyde; a bifunctional epoxide such as 1,4-butaneodiol diglycidyl ether; the bifunctional hydrazides adipic acid dihydrazide, carbohydrazide, and succinic acid dihydrazide; the bifunctional diazoniums o-tolidine, diazotized and bis-diazotized benzidine; the bifunctional alkylhalides N1N'-ethylene-bis(iodoacetamide), N1N'-hexamethylene-bis(iodoacetamide), N1N'-undecamethylene-bis(iodoacetamide), as well as benzylhalides and halomustards, such as a1a'-diiodo-p-xylene sulfonic acid and tri(2-chloroethyl)amine, respectively.

Examples of common hetero-bifunctional cross-linking agents that may be used to effect the conjugation of proteins to peptides include, but are not limited to, SMCC (succinimidyl-4-(N-maleimidomethyl)cyclohexane-1-carboxylate), MBS (m-maleimidobenzoyl-N-hydroxysuccinimide ester), SIAB (N-succinimidyl(4-iodoacteyl)aminobenzoate), SMPB (succinimidyl-4-(p-maleimidophenyl)butyrate), GMBS (N-(γ-maleimidobutyryloxy)succinimide ester), MPBH (4-(4-N-maleimidopohenyl) butyric acid hydrazide), M2C2H (4-(N-maleimidomethyl) cyclohexane-1-carboxyl-hydrazide), SMPT (succinimidyloxycarbonyl-á-methyl-á-(2-pyridyldithio)toluene), and SPDP (N-succinimidyl 3-(2-pyridyldithio)propionate).

Cross-linking may be accomplished by coupling a carbonyl group to an amine group or to a hydrazide group by reductive amination.

Peptides of the invention also may be formulated as non-covalent attachment of monomers through ionic, adsorptive, or biospecific interactions. Complexes of peptides with highly positively or negatively charged molecules may be done through salt bridge formation under low ionic strength environments, such as in deionized water. Large complexes can be created using charged polymers such as poly-(L-glutamic acid) or poly-(L-lysine) which contain numerous negative and positive charges, respectively. Adsorption of peptides may be done to surfaces such as microparticle latex beads or to other hydrophobic polymers, forming non-covalently associated peptide-superantigen complexes effectively mimicking cross-linked or chemically polymerized protein. Finally, peptides may be non-covalently linked through the use of biospecific interactions between other molecules. For instance, utilization of the strong affinity of biotin for proteins such as

avidin or streptavidin or their derivatives could be used to form peptide complexes. These biotin-binding proteins contain four binding sites that can interact with biotin in solution or be covalently attached to another molecule. Wilchek (1988) Anal. Biochem. **171**:1-32. Peptides can be modified to possess biotin groups using common biotinylation reagents such as the N-hydroxysuccinimidyl ester of D-biotin (NHS-biotin) which reacts with available amine groups on the protein. Biotinylated peptides then can be incubated with avidin or streptavidin to create large complexes. The molecular mass of such polymers can be regulated through careful control of the molar ratio of biotinylated peptide to avidin or streptavidin.

Also provided by this application are the peptides and polypeptides described herein conjugated to a detectable agent for use in the diagnostic methods. For example, detectably labeled peptides and polypeptides can be bound to a column and used for the detection and purification of antibodies. They also are useful as immunogens for the production of antibodies, as described below.

The peptides of this invention also can be combined with various liquid phase carriers, such as sterile or aqueous solutions, pharmaceutically acceptable carriers, suspensions and emulsions. Examples of non-aqueous solvents include propyl ethylene glycol, polyethylene glycol and vegetable oils. When used to prepare antibodies, the carriers also can include an adjuvant that is useful to non-specifically augment a specific immune response. A skilled artisan can easily determine whether an adjuvant is required and select one. However, for the purpose of illustration only, suitable adjuvants include, but are not limited to, Freund's Complete and Incomplete, mineral salts and polynucleotides.

This invention further provides polynucleotides encoding polypeptides comprising one or more of the sequences of SEQ ID NOs. 2, 3, 5, 7, and 9, and the complements of these polynucleotides. As used herein, the term "polynucleotide" encompasses DNA, RNA and nucleic acid mimetics. In addition to these polynucleotides, or their complements, this invention also provides the anti-sense polynucleotide stand, *e.g.* antisense RNA to the sequences or their complements. One can obtain an antisense RNA using the sequences provided in SEQ ID NOS. 1, 4, 6, 8, and 10, and the methodology described in Van der Krol, et al. (1988) BioTechnique*s* **6**:958.

The polynucleotides of this invention can be replicated using PCR. PCR technology is the subject matter of United States Patent Nos. 4,683,195; 4,800,159; 4,754,065; and 4,683,202 and described in PCR: THE POLYMERASE CHAIN REACTION (Mullis et al. eds, Birkhauser Press, Boston (1994)) and references cited therein.

Alternatively, one of skill in the art can use the sequences provided herein and a commercial DNA synthesizer to replicate the DNA. Accordingly, this invention also provides a process for obtaining the polynucleotides of this invention by providing the linear sequence of the polynucleotide, appropriate primer molecules, chemicals such as enzymes and instructions for their replication and chemically replicating or linking the nucleotides in the proper orientation to obtain the polynucleotides. In a separate embodiment, these polynucleotides are further isolated. Still further, one of skill in the art can insert the polynucleotide into a suitable replication vector and insert the vector into a suitable host cell (prokaryotic or eukaryotic) for replication and amplification. The DNA so amplified can be isolated from the cell by methods well known to those of skill in the art. A process for obtaining polynucleotides by this method is further provided herein as well as the polynucleotides so obtained.

RNA can be obtained by first inserting a DNA polynucleotide into a suitable host cell. The DNA can be inserted by any appropriate method, *e.g.*, by the use of an appropriate gene delivery vehicle (*e.g.*, liposome, plasmid or vector) or by electroporation. When the cell replicates and the DNA is transcribed into RNA; the RNA can then be isolated using methods well known to those of skill in the art, for example, as set forth in Sambrook et al. (1989) *supra*. For instance, mRNA can be isolated using various lytic enzymes or chemical solutions according to the procedures set forth in Sambrook, et al. (1989) *supra* or extracted by nucleic-acid-binding resins following the accompanying instructions provided by manufactures.

Polynucleotides having at least 4 contiguous nucleotides, and more preferably at least 5 or 6 contiguous nucleotides and most preferably at least 10 contiguous nucleotides, and exhibiting sequence complementarity or homology to the polynucleotides encoding the peptides of SEQ ID NOS. 2 and 3 find utility as hybridization probes.

It is known in the art that a "perfectly matched" probe is not needed for a specific hybridization. Minor changes in probe sequence achieved by substitution, deletion or insertion of a small number of bases do not affect the hybridization specificity. In general, as much as 20% base-pair mismatch (when optimally aligned) can be tolerated. Preferably, a probe useful for detecting the aforementioned mRNA is at least about 80% identical to the homologous region of comparable size contained in the previously identified sequences which correspond to previously characterized genes. More preferably, the probe is 85% identical to the corresponding gene sequence after alignment of the homologous region; even more preferably, it exhibits 90% identity.

These probes can be used in radioassays (*e.g.* Southern and Northern blot analysis) to detect or monitor various cells or tissue containing these cells. The probes also can be attached to a solid support or an array such as a chip for use in high throughput screening assays for the detection of expression of the gene corresponding to one or more polynucleotide(s) of this invention. Accordingly, this invention also provides at least one probe as defined above and or the complement of one of these sequences, attached to a solid support for use in high throughput screens.

The polynucleotides of the present invention also can serve as primers for the detection of genes or gene transcripts that are expressed in APC, for example, to confirm transduction of the polynucleotides into host cells. In this context, amplification means any method employing a primer-dependent polymerase capable of replicating a target sequence with reasonable fidelity. Amplification may be carried out by natural or recombinant DNA-polymerases such as T7 DNA polymerase, Klenow fragment of *E. coli* DNA polymerase, and reverse transcriptase. A preferred length of the primer is the same as that identified for probes, above.

The invention further provides the isolated polynucleotide operatively linked to a promoter of RNA transcription, as well as other regulatory sequences for replication and/or transient or stable expression of the DNA or RNA. As used herein, the term "operatively linked" means positioned in such a manner that the promoter will direct transcription of RNA off the DNA molecule. Examples of such promoters are SP6, T4 and T7. In certain embodiments, cell-specific promoters are used for cell-specific expression of the inserted polynucleotide. Vectors which contain a promoter or a promoter/enhancer, with termination codons and selectable marker sequences, as well as a cloning site into which an inserted piece of DNA can be operatively linked to that promoter are well known in the art and commercially available. For general methodology and cloning strategies, see GENE EXPRESSION TECHNOLOGY (Goeddel ed., Academic Press, Inc. (1991)) and references cited therein and VECTORS: ESSENTIAL DATA SERIES (Gacesa and Ramji, eds., John Wiley & Sons, N.Y. (1994)), which contains maps, functional properties, commercial suppliers and a reference to GenEMBL accession numbers for various suitable vectors. Preferable, these vectors are capable of transcribing RNA *in vitro* or *in vivo*.

Expression vectors containing these nucleic acids are useful to obtain host vector systems to produce proteins and polypeptides. It is implied that these expression vectors must be replicable in the host organisms either as episomes or as an integral part of the chromosomal DNA. Suitable expression vectors include plasmids, viral vectors, including

adenoviruses, adeno-associated viruses, retroviruses, cosmids, etc. Adenoviral vectors are particularly useful for introducing genes into tissues *in vivo* because of their high levels of expression and efficient transformation of cells both *in vitro* and *in vivo*. When a nucleic acid is inserted into a suitable host cell, *e.g.*, a prokaryotic or a eukaryotic cell and the host cell replicates, the protein can be recombinantly produced. Suitable host cells will depend on the vector and can include mammalian cells, animal cells, human cells, simian cells, insect cells, yeast cells, and bacterial cells constructed using well known methods. See Sambrook, et al. (1989) *supra*. In addition to the use of viral vector for insertion of exogenous nucleic acid into cells, the nucleic acid can be inserted into the host cell by methods well known in the art such as transformation for bacterial cells; transfection using calcium phosphate precipitation for mammalian cells; DEAE-dextran; electroporation; or microinjection. See Sambrook et al. (1989) *supra* for this methodology. Thus, this invention also provides a host cell, *e.g.* a mammalian cell, an animal cell (rat or mouse), a human cell, or a prokaryotic cell such as a bacterial cell, containing a polynucleotide encoding a protein or polypeptide or antibody.

The present invention also provides delivery vehicles suitable for delivery of a polynucleotide of the invention into cells (whether *in vivo*, *ex vivo*, or *in vitro*). A polynucleotide of the invention can be contained within a cloning or expression vector. These vectors (especially expression vectors) can in turn be manipulated to assume any of a number of forms which may, for example, facilitate delivery to and/or entry into a cell.

When the vectors are used for gene therapy *in vivo* or *ex vivo*, a pharmaceutically acceptable vector is preferred, such as a replication-incompetent retroviral or adenoviral vector. Pharmaceutically acceptable vectors containing the nucleic acids of this invention can be further modified for transient or stable expression of the inserted polynucleotide. As used herein, the term "pharmaceutically acceptable vector" includes, but is not limited to, a vector or delivery vehicle having the ability to selectively target and introduce the nucleic acid into dividing cells. An example of such a vector is a "replication-incompetent" vector defined by its inability to produce viral proteins, precluding spread of the vector in the infected host cell. An example of a replication-incompetent retroviral vector is LNL6 (Miller A.D. et al. (1989) BioTechniques **7**:980-990). The methodology of using replication-incompetent retroviruses for retroviral-mediated gene transfer of gene markers is well established (Correll et al. (1989) Proc. Natl. Acad. Sci. USA **86**:8912; Bordignon (1989) Proc. Natl. Acad. Sci. USA **86**:8912-52; Culver K. (1991) Proc. Natl. Acad. Sci. USA **88**:3155; and Rill D.R. (1991) Blood **79**(10):2694-2700).

These isolated host cells containing the polynucleotides of this invention are useful for the recombinant replication of the polynucleotides and for the recombinant production of peptides. Alternatively, the cells may be used to induce an immune response in a subject in the methods described herein. When the host cells are antigen presenting cells, they can be used to expand a population of immune effector cells such as tumor infiltrating lymphocytes which in turn are useful in adoptive immunotherapies.

Also provided by this invention is an antibody capable of specifically forming a complex with the polypeptides of this invention. The term "antibody" includes polyclonal antibodies and monoclonal antibodies. The antibodies include, but are not limited to mouse, rat, and rabbit or human antibodies. The antibodies are useful to identify and purify polypeptides and APCs expressing the polypeptides.

Laboratory methods for producing polyclonal antibodies and monoclonal antibodies, as well as deducing their corresponding nucleic acid sequences, are known in the art, see Harlow and Lane (1988) and (1999) *supra* and Sambrook et al. (1989) *supra*. The monoclonal antibodies of this invention can be biologically produced by introducing protein or a fragment thereof into an animal, *e.g.*, a mouse or a rabbit. The antibody producing cells in the animal are isolated and fused with myeloma cells or hetero-myeloma cells to produce hybrid cells or hybridomas. Accordingly, the hybridoma cells producing the monoclonal antibodies of this invention also are provided.

Thus, using the protein or fragment thereof, and well known methods, one of skill in the art can produce and screen the hybridoma cells and antibodies of this invention for antibodies having the ability to bind the proteins or polypeptides.

If a monoclonal antibody being tested binds with the protein or polypeptide, then the antibody being tested and the antibodies provided by the hybridomas of this invention are equivalent. It also is possible to determine without undue experimentation, whether an antibody has the same specificity as the monoclonal antibody of this invention by determining whether the antibody being tested prevents a monoclonal antibody of this invention from binding the protein or polypeptide with which the monoclonal antibody is normally reactive. If the antibody being tested competes with the monoclonal antibody of the invention as shown by a decrease in binding by the monoclonal antibody of this invention, then it is likely that the two antibodies bind to the same or a closely related epitope. Alternatively, one can pre-incubate the monoclonal antibody of this invention with a protein with which it is normally reactive, and determine if the monoclonal antibody being tested is inhibited in its ability to bind the antigen. If the monoclonal antibody being tested

is inhibited then, in all likelihood, it has the same, or a closely related, epitopic specificity as the monoclonal antibody of this invention.

The term "antibody" also is intended to include antibodies of all isotypes. Particular isotypes of a monoclonal antibody can be prepared either directly by selecting from the initial fusion, or prepared secondarily, from a parental hybridoma secreting a monoclonal antibody of different isotype by using the sib selection technique to isolate class switch variants using the procedure described in Steplewski et al. (1985) Proc. Natl. Acad. Sci. USA **82**:8653 or Spira et al. (1984*)* J. Immunol. Meth. **74**:307.

This invention also provides biological active fragments of the polyclonal and monoclonal antibodies described above. These "antibody fragments" retain some ability to selectively bind with its antigen or immunogen. Such antibody fragments can include, but are not limited to:

(1) Fab,

(2) Fab',

(3) $F(ab')_2$,

(4) Fv, and

(5) SCA

A specific example of "a biologically active antibody fragment" is a CDR region of the antibody. Methods of making these fragments are known in the art, see for example, Harlow and Lane (1988) *supra*.

Techniques for making such partially to fully human antibodies are known in the art and any such techniques can be used. According to one particularly preferred embodiment, fully human antibody sequences are made in a transgenic mouse which has been engineered to express human heavy and light chain antibody genes. Multiple strains of such transgenic mice have been made which can produce different classes of antibodies. B cells from transgenic mice which are producing a desirable antibody can be fused to make hybridoma cell lines for continuous production of the desired antibody. See for example, Nina D., et al. (2000) Infection and Immunity April:1820-1826; Gallo, M.L., et al. (2000) European Journal of Immunology **30**: 534-540, Green, L.L. (1999) J. Immun. Methods **231**:11-23; Yang X-D, et al. (1999) J. Leukocyte Biol. **66**: 401-410; Yang X-D, et al. (1999) Cancer Research **59**(6): 1236-1243; Jakobovits A. (1998) Advanced Drug Delivery Reviews **31**: 33-42; Green L and Jakobovits A. (1998) J. Exp. Med. **188**(3):483-495 (1998); Jakobovits A. (1998) Exp. Opin. Invest. Drugs **7(4):** 607-614; Tsuda H, et al. (1997) Genomics **42**:

413-421; Sherman-Gold, R. (1997) **17**(14) (August 1997); Mendez M, et al. (1997) Nature Genetics **15**: 146-156 (1997); Jakobovits A. Mice engineered with human immunoglobulin YACs: A new technology for production of fully human antibodies for autoimmunity therapy. WEIR'S HANDBOOK OF EXPERIMENTAL IMMUNOLOGY, THE INTEGRATED IMMUNE SYSTEM VOL. IV, pp: 194.1-194.7 (1996) ; Jakobovits A. (1995) Current Opinion in Biot. **6**: (5): 561-566; Mendez M, et al. (1995) Genomics **26**:294-307; Jakobovits A. (1994) Current Biol. **4**(8):761-763; Arbones M. et al. (1994) Immunity **1**(4):247-260; Green L, et al. (1994) Nature Genetics **7**(1): 13-21; Jakobovits A, et al. (1993) Nature **362**(6417):255-258; Jakobovits A, et al. (1993) P.N.A.S., USA **90**(6):2551-2555; Kucherlapati et al., U.S. Patent No. 6,1075,181.

Antibodies can also be made using phage display techniques. Such techniques can be used to isolate an initial antibody or to generate variants with altered specificity or avidity characteristics. Single chain Fv can also be used as is convenient. They can be made from vaccinated transgenic mice, if desired. Antibodies can be produced in cell culture, in phage, or in various animals, including but not limited to cows, rabbits, goats, mice, rats, hamsters, guinea pigs, sheep, dogs, cats, monkeys, chimpanzees, apes.

The antibodies of this invention also can be modified to create chimeric antibodies. Chimeric antibodies are those in which the various domains of the antibodies' heavy and light chains are coded for by DNA from more than one species.

The isolation of other hybridomas secreting monoclonal antibodies with the specificity of the monoclonal antibodies of the invention can also be accomplished by one of ordinary skill in the art by producing anti-idiotypic antibodies (Herlyn et al. (1986) Science **232**:100). An anti-idiotypic antibody is an antibody which recognizes unique determinants present on the monoclonal antibody produced by the hybridoma of interest.

Idiotypic identity between monoclonal antibodies of two hybridomas demonstrates that the two monoclonal antibodies are the same with respect to their recognition of the same epitopic determinant. Thus, by using antibodies to the epitopic determinants on a monoclonal antibody it is possible to identify other hybridomas expressing monoclonal antibodies of the same epitopic specificity.

It is also possible to use the anti-idiotype technology to produce monoclonal antibodies which mimic an epitope. For example, an anti-idiotypic monoclonal antibody made to a first monoclonal antibody will have a binding domain in the hypervariable region which is the mirror image of the epitope bound by the first monoclonal antibody. Thus, in

this instance, the anti-idiotypic monoclonal antibody could be used for immunization for production of these antibodies.

As used in this invention, the term "epitope" is meant to include any determinant having specific affinity for the monoclonal antibodies of the invention. Epitopic determinants usually consist of chemically active surface groupings of molecules such as amino acids or sugar side chains and usually have specific three dimensional structural characteristics, as well as specific charge characteristics.

The antibodies of this invention can be linked to a detectable agent or label. There are many different labels and methods of labeling known to those of ordinary skill in the art.

The coupling of antibodies to low molecular weight haptens can increase the sensitivity of the assay. The haptens can then be specifically detected by means of a second reaction. For example, it is common to use haptens such as biotin, which reacts avidin, or dinitropherryl, pyridoxal, and fluorescein, which can react with specific anti-hapten antibodies. See Harlow and Lane (1988) and (1999) *supra*.

The monoclonal antibodies of the invention also can be bound to many different carriers. Thus, this invention also provides compositions containing the antibodies and another substance, active or inert. Examples of well-known carriers include glass, polystyrene, polypropylene, polyethylene, dextran, nylon, amylases, natural and modified celluloses, polyacrylamides, agaroses and magnetite. The nature of the carrier can be either soluble or insoluble for purposes of the invention. Those skilled in the art will know of other suitable carriers for binding monoclonal antibodies, or will be able to ascertain such, using routine experimentation.

Compositions containing the antibodies, fragments thereof or cell lines which produce the antibodies, are encompassed by this invention. When these compositions are to be used pharmaceutically, they are combined with a pharmaceutically acceptable carrier.

In another embodiment the present invention provides a method of inducing an immune response comprising delivering the compounds and compositions of the invention in the context of an MHC molecule. Thus, the polypeptides of this invention can be pulsed into antigen presenting cells using the methods described herein. Antigen-presenting cells, include, but are not limited to dendritic cells (DCs), monocytes/macrophages, B lymphocytes or other cell type(s) expressing the necessary MHC/co-stimulatory molecules. The methods described below focus primarily on DCs which are the most potent, preferred APCs. These host cells containing the polypeptides or proteins are further provided.

Isolated host cells which present the polypeptides of this invention in the context of MHC molecules are further useful to expand and isolate a population of educated, antigen-specific immune effector cells. The immune effector cells, *e.g.*, cytotoxic T lymphocytes, are produced by culturing naïve immune effector cells with antigen-presenting cells which present the polypeptides in the context of MHC molecules on the surface of the APCs. The population can be purified using methods known in the art, *e.g.*, FACS analysis or ficoll gradient. The methods to generate and culture the immune effector cells as well as the populations produced thereby also are the inventor's contribution and invention. Pharmaceutical compositions comprising the cells and pharmaceutically acceptable carriers are useful in adoptive immunotherapy. Prior to administration *in vivo,* the immune effector cells are screened *in vitro* for their ability to lyse cells expressing BGP.

In one embodiment, the immune effector cells and/or the APCs are genetically modified. Using standard gene transfer, genes coding for co-stimulatory molecules and/or stimulatory cytokines can be inserted prior to, concurrent to or subsequent to expansion of the immune effector cells.

This invention also provides methods of inducing an immune response in a subject, comprising administering to the subject an effective amount of the polypeptides or immunogenic portion thereof under the conditions that induce an immune response to the polypeptide. The polypeptides can be administered in formulations or as polynucleotides encoding the polypeptides. The polynucleotides can be administered in a gene delivery vehicle or by inserting into a host cell which in turn recombinantly transcribes, translates and processed the encoded polypeptide. Isolated host cells containing the polynucleotides of this invention in a pharmaceutically acceptable carrier can therefore combined with appropriate and effective amount of an adjuvant, cytokine or co-stimulatory molecule for an effective vaccine regimen. In one embodiment, the host cell is an APC such as a dendritic cell. The host cell can be further modified by inserting of a polynucleotide coding for an effective amount of either or both a cytokine and/or a co-stimulatory molecule.

The methods of this invention can be further modified by co-administering an effective amount of a cytokine or co-stimulatory molecule to the subject.

An "immunogenic portion" of a BGP protein is a portion that is capable of educating T cells that in turn, specifically bind to the BGP protein or antibodies present within sera. Immunogenic portions of the proteins described herein can be identified in antibody binding assays. Such assays are generally be performed using any of a variety of means known to those of ordinary skill in the art, as described, for example, in Harlow and Lane, (1988) and

(1999), supra. For example, an immunogenic portion can be immobilized on a solid support (as described below) and contacted with animal sera to allow binding of antibodies within the sera to the immobilized polypeptide. Unbound sera is removed and bound antibodies detected using, for example, ^{125} I-labeled Protein A. Alternatively, the immunogenic portion is used to generate monoclonal and polyclonal antibodies for use in detection of the polypeptide in blood, other sample fluids, cells or tissues.

A BGP protein or immunogenic portion as defined herein also encompass variants of the sequences shown in SEQ ID NOs: 2 or 3. A polypeptide "variant," as used herein, is a polypeptide that differs from SEQ ID NOs: 2 or 3 only in conservative substitutions and/or modifications, such that the antigenic and/or immunogenic properties of the polypeptide are retained. Variants of SEQ ID NOs: 2 or 3 can also be identified by modifying the amino acid sequence of SEQ ID NOs: 2 or 3, and evaluating the immunoreactivity of the modified polypeptide. For proteins and polypeptides useful for the generation of diagnostic binding agents, a variant can be identified by evaluating a modified polypeptide for the ability to generate antibodies that detect the presence or absence of a neoplastic cell or tissue, more specifically, colon cancer. Such modified sequences can prepared and tested using, for example, the representative procedures described herein.

As used herein, a "conservative substitution" is one in which an amino acid is substituted for another amino acid that has similar properties, such that one skilled in the art of peptide chemistry would expect the secondary structure and hydropathic nature of the polypeptide to be substantially unchanged. In general, the following groups of amino acids represent conservative changes: (1) ala, pro, gly, glu, asp, gln, asn, ser, thr; (2) cys, ser, tyr, thr; (3) val, ile, leu, met, ala, phe; (4) lys, arg, his; and (5) phe, tyr, trp, his. Variants can also comprise other modifications, including the deletion or addition of amino acids that have minimal influence on the antigenic properties, secondary structure and hydropathic nature of the polypeptide. For example, a polypeptide may be conjugated to a signal (or leader) sequence at the N-terminal end of the protein which co-translationally or post-translationally directs transfer of the protein. The polypeptide may also be conjugated to a linker or other sequence for ease of synthesis, purification or identification of the polypeptide (*e.g.*., poly-His), or to enhance binding of the polypeptide to a solid support. For example, a polypeptide can be conjugated to an immunoglobulin Fc region. In an embodiment of the invention an antibody of the invention may be coupled to a bridging compound coupled to a solid support. The bridging compound, which is designed to link

the solid support and the antibody may be hydrazide, Protein A, glutaraldehyde, carbodiimide, or lysine.

The solid support employed is e.g. a polymer or it may be a matrix coated with a polymer. The matrix may be of any suitable solid material, e.g. glass, paper or plastic. The polymer may be a plastic, cellulose such as specially treated paper. nitrocellulose paper or cyanogenbromide-activated paper. Examples of suitable plastics are latex, a polystyrene, polyvinylchloride, polyurethane, polyacrylamide, polyvinylacetate and any suitable copolymer thereof. Examples of silicone polymers include siloxane.

The solid support may be in the form of a tray, a plate such as a mitrotiter plate, e.g. a thin layer or, preferably, strip, film, glass slide, threads, solid particles such as beads, including Protein A-coated bacteria, or paper.

The antibody of the invention may be used in an assay for the identification and/or quantification of at least a form and/or a part of said polypeptide present in a sample. The identification and/or quantification performed by the use according to the present invention may be any identification and/or quantification involving BGP compounds or a form of BGP compounds. Thus, both a qualitative and a quantitative determination of BGP compounds may be obtained according to the use of the present invention. The identification and/or quantification may be performed for both a scientific, a clinical and an industrial purpose. As will be further described below, it is especially important in clinical routine to identify or quantify BGP compounds.

In one embodiment of the invention it is preferred that the antibody used in the method of the invention is a monoclonal antibody as this generally provides a higher precision and accuracy of the assay, at the same time possibly requiring less time to perform. Furthermore, a mixture of two or more different monoclonal antibodies may be employed to increase the detection limit and sensitivity of the test. The monoclonal antibody may be obtained by the method described below. Antibodies possessing high avidity may be selected for catching techniques.

The antibody used in the present method is preferably in substantially pure form (purified according to suitable techniques or by the methods of the invention, see below) in order to improve the precision and/or accuracy of the assays of the invention.

In a further aspect, the invention relates to a diagnostic agent comprising an anti-BGP antibody capable of detecting and/or quantitating BGP or a derivative thereof in a sample.

The antibodies are useful in diagnosis BGP expressing cells and pathologies connected to the expression of BGP, e.g., colon cancer, and other disorders. The fact that the differential expression of BGP is related to the pathological stated makes it a useful diagnostic and prognostic marker. Thus, determination of concentrations of BGP or degradation products thereof in body fluids, such as serum, urine, and ascites fluid may therefore prove to be diagnostically and/or prognostically valuable.

For most assay uses it preferred that the antibody is provided with a label for the detection of bound antibody or, alternatively (such as in a double antibody assay), a combination of labelled and unlabelled antibody may be employed. The substance used as label may be selected from any substance which is in itself detectable or which may be reacted with another substance to produce a detectable product. Thus, the label may be selected from radioactive isotopes, enzymes, chromophores, fluorescent or chemiluminescent substances, and complexing agents.

In an embodiment of the invention an antibody of the invention is coupled to a bridging compound coupled to a solid support. The bridging compound, which is designed to link the solid support and the antibody may be hydrazide, Protein A, glutaraldehyde, carbodiimide, or lysine.

The solid support employed is e.g. a polymer or it may be a matrix coated with a polymer. The matrix may be of any suitable solid material, e.g. glass, paper or plastic. The polymer may be a plastic, cellulose such as specially treated paper. nitrocellulose paper or cyanogenbromide-activated paper. Examples of suitable plastics are latex, a polystyrene, polyvinylchloride, polyurethane, polyacrylamide, polyvinylacetate and any suitable copolymer thereof. Examples of silicone polymers include siloxane.

The solid support may be in the form of a tray, a plate such as a mitrotiter plate, e.g. a thin layer or, preferably, strip, film, threads, solid particles such as beads, including Protein A-coated bacteria, or paper.

The antibody of the invention may be used in an assay for the identification and/or quantification of BGP and/or BGP expressing cells present in a sample. The identification and/or quantification can be performed for both a scientific, a clinical and an industrial purpose. As will be further described below, it is especially important in clinical routine to identify or quantify BGP.

In one preferred embodiment of the invention it is preferred that the antibody used in the method of the invention is a monoclonal antibody. Furthermore, a mixture of two or more different monoclonal antibodies can be employed as this may increase the detection

limit and sensitivity of the test. The monoclonal antibody can be obtained by the method described below. Antibodies possessing high avidity may be selected for catching techniques.

In one embodiment, these neoplasia are diagnosed by evaluating a biological sample obtained from the animal or patient and determining the level of one or more of the above polypeptides, relative to a predetermined cut-off value. As used herein, suitable "biological samples" include colon tissue, blood, stool, sera, urine and/or secretions.

The antibody used in the present method may be in substantially pure form in order to improve the precision and/or accuracy of the assays of the invention. Functional equivalents to the monoclonal antibody, that is, compounds or other ligands that bind the protein and which may inhibit the binding of the antibody to the protein are also provided by this invention.

Another method according to the invention is a method for detecting or quantifying complexes of antibody and BGP in a sample, comprising using, as catching or detecting antibody, an antibody capable of binding to BGP which has bound BGP, together with an antibody which detects bound BGP as detecting or catching antibody, respectively.

Another method according to the invention is a method for immunohistochemical detection of BGP in tissue sections, using, as the detecting antibody, any monoclonal antibody which reacts with BGP, or any polyclonal antibody which reacts with BGP.

The monoclonal antibodies according to the invention may also be used in a method for targeting a diagnostic to a cell that contains a BGP on the surface, the method comprising administering, to a mammal, in particular a human, in particular a mammal suffering from cancer or suspected to suffer from cancer, the diagnostic bound to a monoclonal antibody of the invention against BGP. The diagnostic may be a radioactive substance, such as technetium.

Several embodiments of this invention include but are not limited to: 1) use as a catching antibody when immobilized as a catching antibody in a sandwich ELISA; 2) when used as a biotin-labelled detecting antibody in a sandwich ELISA is capable of detecting BGP; 3) when used in an ELISA, is capable of binding to immobilized BGP; 5) in a radioimmunoprecipitation assay precipitates purified BGP or a fragment thereof; or 8) is capable of binding to BGP in tissue sections, including paraffine-embedded tissue sections, and thereby being useful for immunohistochemical detection of BGP.

A nucleotide, nucleic acid or polynucleotide "variant" of the present invention is a sequence that differs from SEQ ID NOs: 1 or 4 or a portion thereof in having one or more

nucleotide deletions, substitutions or additions. Such modifications can be introduced using standard mutagenesis techniques, such as oligonucleotide-directed site-specific mutagenesis as taught, for example, by Adelman, et al. (1983) DNA **2**:183. Nucleotide variants may be naturally occurring allelic variants, or non-naturally occurring variants. Variant nucleotide sequences preferably exhibit at least about 70%, more preferably at least about 80% and most preferably at least about 90% identity to SEQ ID NOs: 1 or 4. Variant nucleotide sequences will generally hybridize to the recited nucleotide sequence under conditions of high stringency.

Further provided by the present invention are methods for aiding in the detecting, diagnosing, prognosing, and monitoring the progression, course, or stage of BGP -related cancers or malignancies in subjects afflicted therewith. These invention methods comprise detecting the differential expression of a BGP protein in a sample isolated from a cell or tissue, wherein the presence and/or amount of the protein is indicative of the neoplastic condition of cell or tissue. A BGP- related neoplasia is one in which the expression or expression of the protein serves as a marker for the neoplastic phenotype. A test sample which demonstrates the expression of the BGP protein at a level at least twice that observed in a control sample is considered to be indicative of cancer. Samples of cells or tissue can be provided free form or attached to a solid support and can be isolated from a tissue culture, commercially available cell line, from a patient biopsy or as in the case of use of the method for tissue imaging, *in vivo*.

In one aspect, the method is practiced by detecting and/or quantifying mRNA encoding a BGP protein by hybridization or PCR. Modification of current technology enables this method, *e.g.*, detecting is by probing said sample with a probe or primer that specifically hybridizes under conditions of moderate or highly stringent conditions with said BGP mRNA. In one aspect, the probe or primer is detectably labeled. Application of RT-PCR techniques allows for quantitation of BGP mRNA expression. Application of PCR is also useful to detect mutations of BGP.

Examples of suitable probes include but are not limited to a sequence selected from the group consisting of SEQ ID NOs: 1 and 4 and complements thereof; a nucleic acid sequence encoding a peptide selected from the group consisting of SEQ ID NOs: 2 and 3 and complements thereof; and a probe or primer complementary to a sequence encoding an amino acid comprising at least 9 consecutive residues of a protein encoded by a nucleic acid encoding BGP protein, e.g., a sequence recited in SEQ ID NOs: 2 and 3, and complements thereof.

In another aspect, BGP is detected and/or quantified by probing the sample with an agent that specifically recognizes and binds BGP protein. Antibodies, and antigen binding fragments thereof, that specifically recognize or bind to BGP protein are examples of agents. For the purpose of this invention, an antibody is a polyclonal or monoclonal antibody, which may or may not be detectably labeled. Various modifications to antibodies and antigen binding fragments are known in the art and included for the purpose of this invention. Examples are described herein. Suitable monoclonal antibodies for use in this aspect are prepared from an animal immunized with a peptide selected from the group consisting of SEQ ID NOS. 2, 3, 5, 7 and 9. Examples of an antigen binding fragment include a biologically active immunoglobulin variable domain isolated from an antibody prepared from an animal immunized with a peptide selected from the group consisting of SEQ ID NOS. 2, 3, 5, 7, and 9.

The method utilizing antibodies can be practiced *in vitro* or *in vivo*, using application of well known methods as described herein.

In another aspect, the agent is a cell that binds to BGP protein such as an immune effector cell raised in the presence and at the expense of a peptide selected from the group consisting of SEQ. ID NOS. 2, 3, 5, 7, and 9.

Alternatively, differential BGP expression can be detected and/or quantified by determining the identity and expression level of mRNA by expression analysis and comparing the sequences and amount of mRNA to sequences and amount of expression in a normal control cell or tissue, using methods such as expression analysis, *e.g.*, SAGE (United States Pat. No. 5,695,937) and expression arrays.

In another embodiment, detection and analysis of amount of BGP present in a sample is repeated to monitor disease progression, response to a therapeutic regimen, or disease recurrence in a subject. In this aspect, the detecting/monitoring method, as described herein, is performed on one or more sample(s) isolated at one or more times time points subsequent to a prior (control) sample and comparing the amount of protein detected at the subsequent points in time to the amount previously detected in a prior (control) sample.

Additionally, the present invention provides a method of screening compounds to identify those which modulate the activity of the invention compositions. In one aspect, the invention provides an assay to screen for agents that inhibit the binding of BGP protein to its ligand by contacting a sample comprising the protein and ligand under conditions and in the presence of a test agent and detecting any binding between protein and ligand, the

absence of binding being indicative of an agent that modulates the binding of BGP. Alternatively, the invention is useful to screen for agents that enhance the binding of BGP protein to its ligand by contacting a sample comprising the protein and the ligand under conditions and in the presence of a test agent and detecting and comparing any binding between the protein and ligand with a control sample that does not contain the test agent. Enhancement of binding over the control sample is a positive indication that the test agent enhances the binding of BGP to its ligand. Modulation (increase or inhibit) of binding includes a variation in avidity as well as affinity.

For example, one such assay comprises contacting a mammalian cell with an invention composition and the "test compound" and [^{3} H]thymidine, under conditions where the mammalian cell would normally proliferate. A control assay may be performed without the "test compound" and compared to the amount of cell proliferation in the presence of the "test compound" to determine if the compound stimulates or inhibits proliferation. [^{3} H] thymidine uptake can be measured by liquid scintillation chromatography which measures the incorporation of the label. Agonists and antagonist compounds may be identified using this assay.

In an alternative example, a mammalian cell or membrane preparation expressing a binding site or determinant for a polypeptide or peptide of the invention is incubated with a labeled polypeptide or peptide of the invention in the presence of the "test compound". The ability of the "test compound" to enhance or block the interaction of the polypeptide or peptide with its binding site, can be measured. Further the response of a known second messenger system following the interaction of the "test compound" and the binding site is measured and the ability of the "test compound" to bind the site or determinant and elicit a second messenger response can be measured to determine if the "test compound" is a potential agonist or antagonist.

These assays can be used as diagnostic or prognostic markers. The molecules discovered using these screening assays can be used to treat disease or to bring about a particular result in a patient by activating or inhibiting the polypeptide or molecule.

Thus, the invention includes a method of identifying compounds which bind to a polypeptide, peptide, variant or analog of the invention comprising: (a) incubating a candidate test compound with a polypeptide, peptide, variant or analog of the invention; and (b) determining if binding has occurred. The invention further comprises a method of identifying agonists and/or antagonists comprising: (a) incubating a candidate test

compound with a polypeptide, peptide, variant or analog of the invention; (b) assaying a biological activity; and (c) determining if said biological activity has been altered.

Diagnostic kits to practice the methods described herein are also provided. In one aspect, the kit contains at least one agent that specifically recognizes and binds BGP protein and a detection reagent which can support a reporter group. When antibodies are used as the agent, they can be in solution or immobilized on a solid support, such as nitrocellulose, glass, latex or a plastic. Examples of detection reagents include but are not limited to anti-immunoglobulin, protein G, protein A, or lectin. Reporter groups can be provided in the kit, but are not necessarily supplied. Examples of reporter groups suitable for use in the methods include but are not limited to radioisotopes, fluorescent groups, luminescent groups, enzymes, biotin and dye particles.

The kits will contain one or more of binding agents described above, *e.g.*, a probe, a primer, a BGP specific antibody or immune effector cell, or an agent that specifically recognizes binds BGP specific antibody, *e.g.*, antibodies raised and isolated to specifically recognize and bind a peptide selected from the group consisting of SEQ ID NOS. 2, 3, 5, 7 and 9. Instructions for use can also be provided.

The polypeptides of the present invention, *e.g.*, SEQ ID NOS. 2, 3, 5, 7 and 9, can be used to generate binding agents, such as antibodies or fragments thereof, that are capable of detecting neoplastic cells or tissues, or alternatively, for monitoring disease progression in an animal or patient having a neoplastic condition related to the expression of BGP protein, *e.g*, colon cancer. Binding agents of the present invention may generally be prepared using methods known to those of ordinary skill in the art, including the representative procedures described herein. Binding agents are capable of differentiating between patients with and without a neoplastic condition associated with the expression and or overexpression of BGP protein, using the representative assays described herein. In other words, antibodies or other binding agents raised against a BGP protein or fragment thereof will generate a signal indicating the presence of primary or metastatic cancer in patients afflicted with the disease, and will generate a negative signal indicating the absence of the disease in individuals without primary or metastatic disease. Suitable portions of such BGP protein as well as polypeptides shown in SEQ ID NOs: 2, 3, 5, 7,and 9, or portions of SEQ ID NO: 2 that are able to generate a binding agent that indicates the presence of BGP-related neoplasia in substantially all (*i.e.*, at least about 80%, and preferably at least about 90%) of the patients for which such neoplasia would be indicated and that indicates the absence of BGP-related neoplasia in substantially all of those samples that would be

negative when tested with full length protein. The representative assays described below, such as the two-antibody sandwich assay, can be employed for evaluating the ability of a binding agent to detect BGP related neoplasia.

The ability of a polypeptide prepared as described herein to generate antibodies capable of detecting BGP-related neoplasia can be evaluated by raising one or more antibodies against the polypeptide and determining the ability of such antibodies to detect neoplasia in animals or patients. In one aspect, this determination is made by assaying biological samples from animals or patients with and without primary or metastatic BGP-related neoplasia for the presence of a polypeptide that binds to the generated antibodies. Such test assays may be performed, for example, using a representative procedure described below. Polypeptide specific antibodies raised against proteins or polypeptides identified in SEQ ID NOs. 2, 3, 5, 7 and 9, or a fragment thereof, can be used alone or in combination to improve sensitivity.

The level of one or more of invention BGP proteins can be evaluated using any binding agent specific for the polypeptide(s). A "binding agent," in the context of this invention, is any agent (such as a compound or a cell) that binds to a polypeptide as described above. As used herein, "binding" refers to a noncovalent association between two separate molecules (each of which may be free (*i.e.*, in solution) or present on the surface of a cell or a solid support), such that a "complex" is formed. The complex can be free or immobilized (either covalently or noncovalently) on a support material. The ability to bind can be evaluated by determining a binding constant for the formation of the complex. The binding constant is the value obtained when the concentration of the complex is divided by the product of the component concentrations. Binding constants are determined using methods well known to those of ordinary skill in the art.

Any agent that satisfies the above requirements may be a binding agent. For example, a binding agent may be a ribosome with or without a peptide component, an RNA molecule, a host cell expressing epitope, an immune effector cell as described herein or a peptide. In a preferred embodiment, the binding partner is an antibody, or a fragment thereof. The antibodies can be polyclonal or monoclonal which include, but are not limited to single chain, chimeric, CDR-grafted or humanized. Methods for generating these antibodies are well known to those of skill in the art.

This invention also provides compositions containing any of the above-mentioned proteins, polypeptides, polynucleotides, vectors, cells, antibodies and fragments thereof, and an acceptable solid or liquid carrier. When the compositions are used pharmaceutically,

they are combined with a "pharmaceutically acceptable carrier" for diagnostic and therapeutic use. These compositions also can be used for the preparation of medicaments for the diagnosis and treatment of diseases such as cancer.

The following materials and methods are intended to illustrate, but not limit this invention and to illustrate how to make and use the inventions described above.

Materials and Methods

Production of the Polypeptides of the Invention

Most preferably, isolated peptides of the present invention can be synthesized using an appropriate solid state synthetic procedure. Steward and Young, SOLID PHASE PEPTIDE SYNTHESIS, Freemantle, San Francisco, Calif. (1968). A preferred method is the Merrifield process. See, Merrifield (1967) Recent Progress in Hormone Res. **23**:451. The antigenic activity of these peptides may conveniently be tested using, for example, the assays as described herein.

Once an isolated peptide of the invention is obtained, it may be purified by standard methods including chromatography (*e.g.*, ion exchange, affinity, and sizing column chromatography), centrifugation, differential solubility, or by any other standard technique for protein purification. For immuno-affinity chromatography, an epitope may be isolated by binding it to an affinity column comprising antibodies that were raised against that peptide, or a related peptide of the invention, and were affixed to a stationary support.

Alternatively, affinity tags such as hexa-His (Invitrogen), Maltose binding domain (New England Biolabs), influenza coat sequence (Kolodziej et al. (1991) Meth. Enzymol. **194**:508-509), and glutathione-S-transferase can be attached to the peptides of the invention to allow easy purification by passage over an appropriate affinity column. Isolated peptides can also be physically characterized using such techniques as proteolysis, nuclear magnetic resonance, and x-ray crystallography.

Also included within the scope of the invention are antigenic peptides that are differentially modified during or after translation, *e.g.*, by phosphorylation, glycosylation, cross-linking, acylation, proteolytic cleavage, linkage to an antibody molecule, membrane molecule or other ligand, (Ferguson et al. (1988) Ann. Rev. Biochem. **57**:285-320).

Isolation, Culturing and Expansion of APCs, Including Dendritic Cells

The following is a brief description of two fundamental approaches for the isolation of APC. These approaches involve (1) isolating bone marrow precursor cells ($CD34^+$) from

blood and stimulating them to differentiate into APC; or (2) collecting the precommitted APCs from peripheral blood. In the first approach, the patient must be treated with cytokines such as GM-CSF to boost the number of circulating $CD34^+$ stem cells in the peripheral blood.

The second approach for isolating APCs is to collect the relatively large numbers of precommitted APCs already circulating in the blood. Previous techniques for isolating committed APCs from human peripheral blood have involved combinations of physical procedures such as metrizamide gradients and adherence/non-adherence steps (Freudenthal P.S. et al. (1990) Proc. Natl. Acad. Sci. USA **87**:7698-7702); Percoll gradient separations (Mehta-Damani et al. (1994) J. Immunol. **153**:996-1003); and fluorescence activated cell sorting techniques (Thomas R. et al. (1993) J. Immunol. **151**:6840-6852).

One technique for separating large numbers of cells from one another is known as countercurrent centrifugal elutriation (CCE). In this technique, cells are subject to simultaneous centrifugation and a washout stream of buffer that is constantly increasing in flow rate. The constantly increasing countercurrent flow of buffer leads to fractional cell separations that are largely based on cell size.

In one aspect of the invention, the APC are precommitted or mature dendritic cells which can be isolated from the white blood cell fraction of a mammal, such as a murine, simian or a human (See, *e.g.,* WO 96/23060). The white blood cell fraction can be from the peripheral blood of the mammal. This method includes the following steps: (a) providing a white blood cell fraction obtained from a mammalian source by methods known in the art such as leukophoresis; (b) separating the white blood cell fraction of step (a) into four or more subfractions by countercurrent centrifugal elutriation; (c) stimulating conversion of monocytes in one or more fractions from step (b) to dendritic cells by contacting the cells with calcium ionophore, GM-CSF and IL-13 or GM-CSF and IL-4, (d) identifying the dendritic cell-enriched fraction from step (c); and (e) collecting the enriched fraction of step (d), preferably at about 4°C. One way to identify the dendritic cell-enriched fraction is by fluorescence-activated cell sorting. The white blood cell fraction can be treated with calcium ionophore in the presence of other cytokines, such as recombinant (rh) rhIL-12, rhGM-CSF, or rhIL-4. The cells of the white blood cell fraction can be washed in buffer and suspended in Ca^{++}/Mg^{++} free media prior to the separating step. The white blood cell fraction can be obtained by leukapheresis. The dendritic cells can be identified by the presence of at least one of the following markers: HLA-DR, HLA-DQ, or B7. 2, and the

simultaneous absence of the following markers: CD3, CD14, CD16, 56, 57, and CD 19, 20. Monoclonal antibodies specific to these cell surface markers are commercially available.

More specifically, the method requires collecting an enriched collection of white cells and platelets from leukapheresis that is then further fractionated by countercurrent centrifugal elutriation (CCE) (Abrahamsen T.G. et al. (1991) J. Clin. Apheresis. **6**:48-53). Cell samples are placed in a special elutriation rotor. The rotor is then spun at a constant speed of, for example, 3000 rpm. Once the rotor has reached the desired speed, pressurized air is used to control the flow rate of cells. Cells in the elutriator are subjected to simultaneous centrifugation and a washout stream of buffer that is constantly increasing in flow rate. This results in fractional cell separations based largely but not exclusively on differences in cell size.

Quality control of APC and more specifically DC collection and confirmation of their successful activation in culture is dependent upon a simultaneous multi-color FACS analysis technique which monitors both monocytes and the dendritic cell subpopulation as well as possible contaminant T lymphocytes. It is based upon the fact that DCs do not express the following markers: CD3 (T cell); CD14 (monocyte); CD16, 56, 57 (NK/LAK cells); CD19, 20 (B cells). At the same time, DCs do express large quantities of HLA-DR, significant HLA-DQ and B7.2 (but little or no B7.1) at the time they are circulating in the blood (in addition they express Leu M7 and M9, myeloid markers which are also expressed by monocytes and neutrophils).

When combined with a third color reagent for analysis of dead cells, propridium iodide (PI), it is possible to make positive identification of all cell subpopulations (see Table 1):

TABLE 1

FACS analysis of fresh peripheral cell subpopulations

	Color #1	Color #2	Color #3
	Cocktail 3/14/16/19/20/56/57	HLA-DR	PI
Live Dendritic cells	Negative	Positive	Negative
Live Monocytes	Positive	Positive	Negative
Live Neutrophils	Negative	Negative	Negative
Dead Cells	Variable	Variable	Positive

Additional markers can be substituted for additional analysis:
Color #1: CD3 alone, CD14 alone, etc.; Leu M7 or Leu M9; anti-Class I, etc.
Color #2: HLA-DQ, B7.1, B7.2, CD25 (IL2r), ICAM, LFA-3, etc.

The goal of FACS analysis at the time of collection is to confirm that the DCs are enriched in the expected fractions, to monitor neutrophil contamination, and to make sure that appropriate markers are expressed. This rapid bulk collection of enriched DCs from human peripheral blood, suitable for clinical applications, is absolutely dependent on the analytic FACS technique described above for quality control. If need be, mature DCs can be immediately separated from monocytes at this point by fluorescent sorting for "cocktail negative" cells. It may not be necessary to routinely separate DCs from monocytes because, as will be detailed below, the monocytes themselves are still capable of differentiating into DCs or functional DC-like cells in culture.

Once collected, the DC rich/monocyte APC fractions (usually 150 through 190) can be pooled and cryopreserved for future use, or immediately placed in short term culture.

Alternatively, others have reported a method for upregulating (activating) dendritic cells and converting monocytes to an activated dendritic cell phenotype. This method involves the addition of calcium ionophore to the culture media convert monocytes into activated dendritic cells. Adding the calcium ionophore A23187, for example, at the beginning of a 24-48 hour culture period resulted in uniform activation and dendritic cell phenotypic conversion of the pooled "monocyte plus DC" fractions: characteristically, the

activated population becomes uniformly CD14 (Leu M3) negative, and upregulates HLA-DR, HLA-DQ, ICAM-1, B7.1, and B7.2. Furthermore, this activated bulk population functions as well on a small numbers basis as a further purified.

Specific combination(s) of cytokines have been used successfully to amplify (or partially substitute) for the activation/conversion achieved with calcium ionophore: these cytokines include but are not limited to purified or recombinant ("rh") rhGM-CSF, rhIL-2, and rhIL-4. Each cytokine when given alone is inadequate for optimal upregulation.

Presentation of Antigen to the APC

For purposes of immunization, the antigenic peptides (SEQ ID Nos. 2, 3, 5, 7, and 9) can be delivered to antigen-presenting cells as protein/peptide or in the form of cDNA encoding the protein/peptide. Antigen-presenting cells (APCs) can consist of dendritic cells (DCs), monocytes/macrophages, B lymphocytes or other cell type(s) expressing the necessary MHC/co-stimulatory molecules. The methods described below focus primarily on DCs which are the most potent, preferred APCs.

Pulsing is accomplished *in vitro/ex vivo* by exposing APCs to the antigenic protein or peptide(s) of this invention. The protein or peptide(s) are added to APCs at a concentration of 1-10 μm for approximately 3 hours. Pulsed APCs can subsequently be administered to the host via an intravenous, subcutaneous, intranasal, intramuscular or intraperitoneal route of delivery.

Protein/peptide antigen can also be delivered *in vivo* with adjuvant via the intravenous, subcutaneous, intranasal, intramuscular or intraperitoneal route of delivery.

Paglia et al. (1996) J. Exp. Med. **183**:317-322 has shown that APC incubated with whole protein *in vitro* were recognized by MHC class I-restricted CTLs, and that immunization of animals with these APCs led to the development of antigen-specific CTLs *in vivo*. In addition, several different techniques have been described which lead to the expression of antigen in the cytosol of APCs, such as DCs. These include (1) the introduction into the APCs of RNA isolated from tumor cells, (2) infection of APCs with recombinant vectors to induce endogenous expression of antigen, and (3) introduction of tumor antigen into the DC cytosol using liposomes. (See Boczkowski D. et al. (1996) J. Exp. Med. **184**:465-472; Rouse et al. (1994) J. Virol. **68**:5685-5689; and Nair et al. (1992) J. Exp. Med. **175**:609-612).

Foster Antigen Presenting Cells

Foster antigen presenting cells are particularly useful as target cells. Foster APCs are derived from the human cell line 174xCEM.T2, referred to as T2, which contains a mutation in its antigen processing pathway that restricts the association of endogenous peptides with cell surface MHC class I molecules (Zweerink et al. (1993) J. Immunol. **150**:1763-1771). This is due to a large homozygous deletion in the MHC class II region encompassing the genes TAP1, TAP2, LMP1, and LMP2, which are required for antigen presentation to MHC class 1-restricted $CD8^+$ CTLs. In effect, only "empty" MHC class I molecules are presented on the surface of these cells. Exogenous peptide added to the culture medium binds to these MHC molecules provided that the peptide contains the allele-specific binding motif. These T2 cells are referred to herein as "foster" APCs. They can be used in conjunction with this invention to present antigen(s).

Transduction of T2 cells with specific recombinant MHC alleles allows for redirection of the MHC restriction profile. Libraries tailored to the recombinant allele will be preferentially presented by them because the anchor residues will prevent efficient binding to the endogenous allele.

High level expression of MHC molecules makes the APC more visible to the CTLs. Expressing the MHC allele of interest in T2 cells using a powerful transcriptional promoter (*e.g.*, the CMV promoter) results in a more reactive APC (most likely due to a higher concentration of reactive MHC-peptide complexes on the cell surface).

Immunogenicity Assays.

The immunogenicity of invention ligands can be determined by well known methodologies including, but not limited to those exemplified below. In one embodiment, such methodology may be employed to compare ligands of the invention with the corresponding native antigenic epitope.

^{51}Cr-release lysis assay. Lysis of peptide-pulsed ^{51}Cr-labeled targets by antigen-specific T cells can be compared for target cells pulsed with the invention ligands. Ligands that are "more active" will show greater lysis of targets as a function of time. The kinetics of lysis as well as overall target lysis at a fixed timepoint (*e.g.*, 4 hours) may be used to evaluate ligand performance. (Ware C.F. et al. (1983) J. Immunol. **131**:1312).

Cytokine-release assay. Analysis of the types and quantities of cytokines secreted by T cells upon contacting ligand-pulsed targets can be a measure of functional activity. Cytokines can be measured by ELISA or ELISPOT assays to determine the rate and total

amount of cytokine production. (Fujihashi K. et al. (1993) J. Immunol. Meth. **160**:181; Tanquay S. and Killion J.J. (1994) Lymphokine Cytokine Res. **13**:259).

***In vitro* T cell education.** The ligands of the invention can be assayed for the ability to elicit ligand-reactive T cell populations from normal donor or patient-derived PBMC. In this system, elicited T cells can be tested for lytic activity, cytokine-release, polyclonality, and cross-reactivity to the native antigenic epitope. (Parkhurst M.R. et al. (1996) J. Immunol. **157**:2539).

Transgenic animal models. Immunogenicity can be assessed *in vivo* by vaccinating HLA transgenic mice with the ligands of the invention and determining the nature and magnitude of the induced immune response. Alternatively, the hu-PBL-SCID mouse model allows reconstitution of a human immune system in a mouse by adoptive transfer of human PBL. These animals may be vaccinated with the ligands and analyzed for immune response as previously mentioned. (Shirai M. et al. (1995) J. Immunol. **154**:2733; Mosier D.E. et al. (1993) Proc. Natl. Acad. Sci. USA **90**:2443).

Proliferation. T cells will proliferate in response to reactive ligands. Proliferation can be monitored quantitatively by measuring, for example, ^{3}H-thymidine uptake. (Caruso A. et al. (1997) Cytometry **27**:71).

Tetramer staining. MHC tetramers can be loaded with individual ligands and tested for their relative abilities to bind to appropriate effector T cell populations. (Altman J.D. et al. (1996) Science **274**:5284).

MHC Stabilization. Exposure of certain cell lines such as T2 cells to HLA-binding ligands results in the stabilization of MHC complexes on the cell surface. Quantitation of MHC complexes on the cell surface has been correlated with the affinity of the ligand for the HLA allele that is stabilized. Thus, this technique can determine the relative HLA affinity of ligand epitopes. (Stuber G. et al. (1995) Int. Immunol. **7**:653).

MHC competition. The ability of a ligand to interfere with the functional activity of a reference ligand and its cognate T cell effectors is a measure of how well a ligand can compete for MHC binding. Measuring the relative levels of inhibition is an indicator of MHC affinity. (Feltkamp M.C. et al. (1995) Immunol. Lett. **47**:1).

Primate models. A recently described non-human primate (chimpanzee) model system can be utilized to monitor *in vivo* immunogenicities of HLA-restricted ligands. It has been demonstrated that chimpanzees share overlapping MHC-ligand specificities with human MHC molecules thus allowing one to test HLA-restricted ligands for relative *in vivo* immunogenicity. (Bertoni R. et al. (1998) J. Immunol. **161**:4447).

Monitoring TCR Signal Transduction Events. Several intracellular signal transduction events (*e.g.*, phosphorylation) are associated with successful TCR engagement by MHC-ligand complexes. The qualitative and quantitative analysis of these events have been correlated with the relative abilities of ligands to activate effector cells through TCR engagement. (Salazar E. et al. (2000) Int. J. Cancer **85**:829; Isakov N. et al. (1995) J. Exp. Med. **181**:375).

Additional assays for determining the activity of the invention polypeptides, peptides, variants and analogs thereof, are known in the art.

For example, to determine the ability of a polypeptide, peptide, variant or analog, to compete with another peptide for binding to an antibody, various immunoassays can be employed, including but not limited to, competitive and non-competitive assay systems using technologies such as radioimmunoassays, ELISA, immunoradiometric assays, gel diffusion precipitation reactions, immunodiffusion assays, *in situ* immunoassays, Western Blot, precipitation reactions, agglutination assays, immunofluorescence assays, protein A assays, electrophoretic assays, and the like. Binding may also be detected using antibody capture assays, antigen capture assays, and multiple-antibody sandwich assays. Methods for detecting binding in such assays are known in the art.

Expansion of Immune Effector Cells

The present invention makes use of these APCs to stimulate production of an enriched population of antigen-specific immune effector cells. The antigen-specific immune effector cells are expanded at the expense of the APCs, which die in the culture. The process by which naïve immune effector cells become educated by other cells is described essentially in Coulie (1997) Molec. Med. Today **3**:261-268.

The APCs prepared as described above are mixed with naïve immune effector cells. Preferably, the cells may be cultured in the presence of a cytokine, for example IL2. Because dendritic cells secrete potent immunostimulatory cytokines, such as IL12, it may not be necessary to add supplemental cytokines during the first and successive rounds of expansion. In any event, the culture conditions are such that the antigen-specific immune effector cells expand (*i.e.*, proliferate) at a much higher rate than the APCs. Multiple infusions of APCs and optional cytokines can be performed to further expand the population of antigen-specific cells.

In one embodiment, the immune effector cells are T cells. In a separate embodiment, the immune effector cells can be genetically modified by transduction with a

transgene coding for example, IL-2, IL-11 or IL-13. Methods for introducing transgenes *in vitro*, *ex vivo* and *in vivo* are well known in the art. See Sambrook et al. (1989) *supra*.

Vectors Useful in Genetic Modifications

In general, genetic modifications of cells employed in the present invention are accomplished by introducing a vector containing a polypeptide or transgene encoding a heterologous or an altered antigen. A variety of different gene transfer vectors, including viral as well as non-viral systems can be used. Viral vectors useful in the genetic modifications of this invention include, but are not limited to adenovirus, adeno-associated virus vectors, retroviral vectors and adeno-retroviral chimeric vectors. APC and immune effector cells can be modified using the methods described below or by any other appropriate method known in the art.

Construction of Recombinant Adenoviral Vectors or Adeno-Associated Virus Vectors

Adenovirus and adeno-associated virus vectors useful in the genetic modifications of this invention may be produced according to methods already taught in the art. See, *e.g.*, Karlsson et al. (1986) EMBO J. **5**:2377; Carter (1992) Curr. Op. Biotechnol. **3**:533-539; Muzcyzka (1992) Current Top. Microbiol. Immunol. **158**:97-129; GENE TARGETING: A PRACTICAL APPROACH (1992) ed. A. L. Joyner, Oxford University Press, NY). Several different approaches are feasible. Preferred is the helper-independent replication deficient human adenovirus system..

The recombinant adenoviral vectors based on the human adenovirus 5 (Virology **163**:614-617 (1988)) are missing essential early genes from the adenoviral genome (usually E1A/E1B), and are therefore unable to replicate unless grown in permissive cell lines that provide the missing gene products *in trans*. In place of the missing adenoviral genomic sequences, a transgene of interest can be cloned and expressed in cells infected with the replication deficient adenovirus. Although adenovirus-based gene transfer does not result in integration of the transgene into the host genome (less than 0.1% adenovirus-mediated transfections result in transgene incorporation into host DNA), and therefore is not stable, adenoviral vectors can be propagated in high titer and transfect non-replicating cells. Human 293 cells, which are human embryonic kidney cells transformed with adenovirus E1A/E1B genes, typify useful permissive cell lines. However, other cell lines which allow replication-deficient adenoviral vectors to propagate therein can be used, including HeLa cells.

Additional references describing adenovirus vectors and other viral vectors which could be used in the methods of the present invention include the following: Horwitz M.S. ADENOVIRIDAE AND THEIR REPLICATION, in Fields B. et al. (eds.) VIROLOGY, Vol. 2, Raven Press New York, pp. 1679-1721 (1990); Graham F. et al. pp. 109-128 in METHODS IN MOLECULAR BIOLOGY, Vol. 7: GENE TRANSFER AND EXPRESSION PROTOCOLS, Murray E. (ed.) Humana Press, Clifton, N.J. (1991); Miller N. et al. (1995) FASEB J. **9**:190-199; Schreier H. (1994) Pharmaceutica Acta Helvetiae **68**:145-159; Schneider and French (1993) Circulation **88**:1937-1942; Curiel D.T. et al.(1992) Hum. Gene Ther. **3**:147-154; Graham F.L. et al. WO 95/00655 (5 January 1995); Falck-Pedersen E.S. WO 95/16772 (22 June 1995); Denefle P. et al. WO 95/23867 (8 September 1995); Haddada H. et al. WO 94/26914 (24 November 1994); Perricaudet M. et al. WO 95/02697 (26 January 1995); Zhang W. et al. WO 95/25071 (12 October 1995). A variety of adenovirus plasmids are also available from commercial sources, including, *e.g.*, Microbix Biosystems of Toronto, Ontario (see, *e.g.*, Microbix Product Information Sheet: Plasmids for Adenovirus Vector Construction, 1996). See also, the papers by Vile et al. (1997) Nature Biotechnology **15**:840-841; and Feng et al. (1997) Nature Biotechnology **15**:866-870, describing the construction and use of adeno-retroviral chimeric vectors that can be employed for genetic modifications.

Additional references describing AAV vectors that could be used in the methods of the present invention include the following: Carter B. HANDBOOK OF PARVOVIRUSES, Vol. **I**, pp. 169-228, 1990; Berns, VIROLOGY, pp. 1743-1764 (Raven Press 1990); Carter B. (1992) Curr. Opin. Biotechnol. **3**:533-539; Muzyczka N. (1992) Current Topics in Micro. and Immunol, **158**:92-129; Flotte T.R. et al. (1992) Am. J. Respir. Cell Mol. Biol. **7**:349-356; Chatterjee et al. (1995) Ann. NY Acad. Sci. **770**:79-90; Flotte T.R. et al. WO 95/13365 (18 May 1995); Trempe J.P. et al., WO 95/13392 (18 May 1995); Kotin R.(1994) Hum. Gene Ther. **5**:793-801; Flotte T.R. et al. (1995) Gene Therapy **2**:357-362; Allen J.M. WO 96/17947 (13 June 1996); and Du et al. (1996) Gene Therapy **3**:254-261.

APCs can be transduced with viral vectors encoding a relevant polypeptides. The most common viral vectors include recombinant poxviruses such as vaccinia and fowlpox virus (Bronte et al. (1997) Proc. Natl. Acad. Sci. USA **94**:3183-3188; Kim et al. (1997) J. Immunother. **20**:276-286) and, preferentially, adenovirus (Arthur et al. (1997) J. Immunol. **159**:1393-1403; Wan et al. (1997) Human Gene Therapy **8**:1355-1363; Huang et al. (1995) J. Virol. **69**:2257-2263). Retrovirus also may be used for transduction of human APCs (Marin et al. (1996) J. Virol. **70**:2957-2962).

In vitro/ex vivo, exposure of human DCs to adenovirus (Ad) vector at a multiplicity of infection (MOI) of 500 for 16-24 h in a minimal volume of serum-free medium reliably gives rise to transgene expression in 90-100% of DCs. The efficiency of transduction of DCs or other APCs can be assessed by immunofluorescence using fluorescent antibodies specific for the tumor antigen being expressed (Kim et al. (1997) J. Immunother. **20**:276-286). Alternatively, the antibodies can be conjugated to an enzyme (*e.g.*, HRP) giving rise to a colored product upon reaction with the substrate. The actual amount of antigenic polypeptides being expressed by the APCs can be evaluated by ELISA.

Transduced APCs can subsequently be administered to the host via an intravenous, subcutaneous, intranasal, intramuscular or intraperitoneal route of delivery.

In vivo transduction of DCs, or other APCs, can be accomplished by administration of Ad (or other viral vectors) via different routes including intravenous, intramuscular, intranasal, intraperitoneal or cutaneous delivery. The preferred method is cutaneous delivery of Ad vector at multiple sites using a total dose of approximately $1x10^{10}$-$1x\ 10^{12}$ i.u. Levels of *in vivo* transduction can be roughly assessed by co-staining with antibodies directed against APC marker(s) and the TAA being expressed. The staining procedure can be carried out on biopsy samples from the site of administration or on cells from draining lymph nodes or other organs where APCs (in particular DCs) may have migrated (Condon et al. (1996) Nature Med. **2**:1122-1128 and Wan et al. (1997) Hum. Gene Ther. **8**:1355-1363). The amount of antigen being expressed at the site of injection or in other organs where transduced APCs may have migrated can be evaluated by ELISA on tissue homogenates.

Although viral gene delivery is more efficient, DCs can also be transduced *in vitro/ex vivo* by non-viral gene delivery methods such as electroporation, calcium phosphate precipitation or cationic lipid/plasmid DNA complexes (Arthur et al. (1997) Cancer Gene Ther. **4**:17-25). Transduced APCs can subsequently be administered to the host via an intravenous, subcutaneous, intranasal, intramuscular or intraperitoneal route of delivery.

In vivo transduction of DCs, or other APCs, can potentially be accomplished by administration of cationic lipid/plasmid DNA complexes delivered via the intravenous, intramuscular, intranasal, intraperitoneal or cutaneous route of administration. Gene gun delivery or injection of naked plasmid DNA into the skin also leads to transduction of DCs (Condon et al. (1996) Nature Med. **2**:1122-1128; Raz et al (1994) Proc. Natl. Acad. Sci. USA **91**:9519-9523). Intramuscular delivery of plasmid DNA may also be used for immunization (Rosato et al. (1997) Hum. Gene Ther. **8**:1451-1458.)

The transduction efficiency and levels of transgene expression can be assessed as described above for viral vectors.

Adoptive Immunotherapy and Vaccines

The expanded populations of antigen-specific immune effector cells of the present invention also find use in adoptive immunotherapy regimes and as vaccines.

Adoptive immunotherapy methods involve, in one aspect, administering to a subject a substantially pure population of educated, antigen-specific immune effector cells made by culturing naïve immune effector cells with APCs as described above. Preferably, the APCs are dendritic cells.

In one embodiment, the adoptive immunotherapy methods described herein are autologous. In this case, the APCs are made using parental cells isolated from a single subject. The expanded population also employs T cells isolated from that subject. Finally, the expanded population of antigen-specific cells is administered to the same patient.

In a further embodiment, APCs or immune effector cells are administered with an effective amount of a stimulatory cytokine, such as IL-2 or a co-stimulatory molecule.

The agents identified herein as effective for their intended purpose can be administered to subjects having tumors expressing BGP as well as or in addition to individuals susceptible to or at risk of developing such tumors. When the agent is administered to a subject such as a mouse, a rat or a human patient, the agent can be added to a pharmaceutically acceptable carrier and systemically or topically administered to the subject. To determine patients that can be beneficially treated, a tumor regression can be assayed. Therapeutic amounts can be empirically determined and will vary with the pathology being treated, the subject being treated and the efficacy and toxicity of the therapy.

Administration *in vivo* can be effected in one dose, continuously or intermittently throughout the course of treatment. Methods of determining the most effective means and dosage of administration are well known to those of skill in the art and will vary with the composition used for therapy, the purpose of the therapy, the target cell being treated, and the subject being treated. Single or multiple administrations can be carried out with the dose level and pattern being selected by the treating physician. Suitable dosage formulations and methods of administering the agents can be found below.

The agents and compositions of the present invention can be used in the manufacture of medicaments and for the treatment of humans and other animals by administration in

accordance with conventional procedures, such as an active ingredient in pharmaceutical compositions.

More particularly, an agent of the present invention also referred to herein as the active ingredient, may be administered for therapy by any suitable route including nasal, topical (including transdermal, aerosol, buccal and sublingual), parental (including subcutaneous, intramuscular, intravenous and intradermal) and pulmonary. It will also be appreciated that the preferred route will vary with the condition and age of the recipient, and the disease being treated.

The preceding discussion and examples are intended merely to illustrate the art. As is apparent to one of skill in the art, various modifications can be made to the above without departing from the spirit and scope of this invention.

CLAIMS

What is claimed is:

1. A composition comprising at least one immunogenic ligand, wherein said immunogenic ligand is individually characterized by an ability to elicit an immune response against the same native ligand, and wherein said immunogenic ligand is selected from the group consisting of SEQ ID NOs.: 3, 5, 7, and 9.

2. The composition of claim 1, further comprising a carrier.

3. The composition of claim 2, wherein the carrier is a pharmaceutically acceptable carrier.

4. A host cell comprising at least one immunogenic ligand, wherein said immunogenic ligand is individually characterized by an ability to elicit an immune response against the same native ligand, and wherein said immunogenic ligand is selected from the group consisting of SEQ ID NOs.:3, 5, 7, and 9.

5. The host cell of claim 4, wherein the host cell is an antigen presenting cell and the immunogenic ligands are presented on the surface of the cell.

6. The host cell of claim 5, wherein the antigen presenting cell is a dendritic cell.

7. A composition comprising the host cell of any one of claims 4 to 6 and a carrier.

8. The composition of claim 7, wherein the carrier is a pharmaceutically acceptable carrier.

9. A method for inducing an immune response in a subject, comprising delivering to the subject a composition comprising an effective amount of at least one immunogenic ligand, wherein each of said immunogenic ligands is characterized by an ability to elicit an immune response against the same native ligand, and wherein said immunogenic ligand is selected from the group consisting of SEQ ID NOs.: 3, 5, 7, and 9 and an immunogenic portion of SEQ ID No. 2.

10. The method of claim 9, wherein said ligand is delivered as a polynucleotide encoding the ligand.

11. A method of aiding in the diagnosis of the neoplastic condition or susceptibility to a neoplastic condition of an animal cell or tissue comprising: determining the amount of expression of a BGP protein in a test sample isolated from said cell or tissue, and diagnosing a neoplastic condition or susceptibility to a neoplastic condition based on the amount of expression of the BGP protein.

12. The method of claim 11, wherein the amount of expression of said protein is determined by detecting the amount of mRNA transcribing said protein.

13. The method of claim 12, wherein said detecting is by probing said test sample with a probe or primer that specifically hybridizes under conditions of moderate or highly stringent conditions with said BGP mRNA.

14. The method of claim 13, wherein said probe or primer comprises a nucleic acid encoding a sequence that is complementary to a sequence encoding at least 9 consecutive amino acid residues of SEQ ID NO: 2, or its complement.

15. The method of claim 14, wherein said probe or primer is immobilized on a solid support.

16. The method of claim 14, wherein said probe or primer is detectably labeled.

17. The method of claim 14, wherein said probe or primer comprises a sequence consisting of at least 9 consecutive polynucleotides of SEQ ID NO: 1 or SEQ ID NO: 4, and complements of these sequences.

18. The method of claim 14, wherein said probe or primer comprises a nucleic acid sequence encoding a peptide selected from the group consisting of SEQ ID NOs.: 1 or 4, and complements of nucleic acids encoding said peptides.

19. The method of claim 11, wherein said expression is at least 2 fold greater than in normal or control sample.

20. The method of claim 11, wherein said detected is determined by probing said sample with an agent that specifically recognizes and binds said protein.

21. The method of claim 20, wherein said agent comprises a biologically active immunoglobulin variable domain that specifically recognizes or binds to said protein or an antigen binding fragment thereof.

22. The method of claim 20, wherein said agent is a polyclonal or monoclonal antibody.

23. The method of claim 20, wherein said agent is a cell that binds to said protein.

24. The method of claim 23, wherein said cell is an immune effector cell raised in the presence and at the expense of a peptide selected from the group consisting of SEQ ID NOs.: 2, 3, 5, 7, and 9.

25. The method of claim 11, wherein said test sample is isolated from colon tissue.

26. The method of claim 25 wherein said detecting is by *in vivo* imaging.

27. The method of claim 22 wherein said monoclonal antibody is prepared from an animal immunized with a peptide selected from the group consisting of SEQ ID NOs.: 2, 3, 5, 7, and 9.

28. The method of claim 20, wherein said agent comprises a biologically active immunoglobulin variable domain isolated from an antibody prepared from an animal immunized with a peptide selected from the group consisting of SEQ ID NOs.: 2, 3, 5, 7, and 9.

29. The method of claim 13, wherein said detection is by polymerase chain reaction or by hybridization assay.

30. The method of claim 15, wherein said solid support is a microchip array or glass slide.

31. The method of claim 11, wherein expression of said protein is by determining the identity and expression level of mRNA by expression analysis and comparing the sequences and amount of mRNA to expression analysis of a control sample.

32. A diagnostic kit comprising at least one agent that specifically recognizes and binds BGP protein and instructions for detecting binding between said BGP protein in a test sample and said agent.

33. A kit of claim 32, wherein said agent is immobilized on a solid support.

34. A kit of claim 33, wherein said solid support is selected from the group consisting of nitrocellulose, latex, glass, plastic and a microchip array.

35. A kit of claim 33, wherein said agent is an antibody and said detection reagent comprises an anti-immunoglobulin, protein G, protein A, or lectin.

36. A kit of claim 32, wherein said detecting is selected from the group consisting of radioisotopes, fluorescent groups, luminescent groups, enzymes, biotin and dye particles.

37. A diagnostic kit comprising a probe or primer of claim 13.

38. An assay to screen for agents that modulate the binding of BGP protein to its ligand comprising contacting a sample comprising said protein and said ligand under conditions and in the presence of a test agent and detecting any binding between said protein and said ligand, a change in said binding being indicative of an agent that modulates the binding of BGP.

39. The assay of claim 38, wherein said modulation comprises increased avidity or affinity between said agent and said protein.

40. A composition comprising a polynucleotide encoding at least one immunogenic ligand, wherein said immunogenic ligand is individually characterized by an ability to elicit an immune response against the same native ligand, and wherein said immunogenic ligand is selected from the group consisting of SEQ ID NOs.: 2, 3, 5, 7, and 9.

41. The composition of claim 40, further comprising a carrier.

42. The composition of claim 41, wherein the carrier is a pharmaceutically acceptable carrier.

43. A host cell comprising a polynucleotide encoding at least one immunogenic ligand, wherein said immunogenic ligand is individually characterized by an ability to elicit

an immune response against the same native ligand, and wherein said immunogenic ligand is selected from the group consisting of SEQ ID NOs.:2, 3, 5, 7, and 9.

44. The host cell of claim 43, wherein the host cell is an antigen presenting cell and the immunogenic ligands are presented on the surface of the cell.

45. The host cell of claim 44, wherein the antigen presenting cell is a dendritic cell.

46. A composition comprising the host cell of any one of claims 43 to 45 and a carrier.

47. The composition of claim 46, wherein the carrier is a pharmaceutically acceptable carrier.

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SEQUENCE LISTING

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templst

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        35                  40                  45
Pro Arg Asp Tyr Phe Phe Ala Leu Ala His Thr Val Arg Asp His Leu
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Val Gly Arg Trp Ile Arg Thr Gln Gln His Tyr Tyr Glu Arg Asp Pro
65                  70                  75                  80
Lys Arg Ile Tyr Tyr Leu Ser Leu Glu Phe Tyr Met Gly Arg Thr Leu
                85                  90                  95
Gln Asn Thr Met Val Asn Leu Gly Leu Gln Asn Ala Cys Asp Glu Ala
            100                 105                 110
Ile Tyr Gln Leu Gly Leu Asp Leu Glu Glu Leu Glu Glu Ile Glu Glu
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Asp Ala Gly Leu Gly Asn Gly Gly Leu Gly Arg Leu Ala Ala Cys Phe
    130                 135                 140
Leu Asp Ser Met Ala Thr Leu Gly Leu Ala Ala Tyr Gly Tyr Gly Ile
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Arg Tyr Glu Phe Gly Ile Phe Asn Gln Lys Ile Val Asn Gly Trp Gln
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            180                 185                 190
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His Thr Pro Asp Gly Val Lys Trp Leu Asp Thr Gln Val Val Leu Ala
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225                 230                 235                 240
Thr Met Arg Leu Trp Ser Ala Arg Ala Pro Asn Asp Phe Lys Leu Gln
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Asp Phe Asn Val Gly Asp Tyr Ile Glu Ala Val Leu Asp Arg Asn Leu
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Ala Glu Asn Ile Ser Arg Val Leu Tyr Pro Asn Asp Asn Phe Phe Glu
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templst

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355 360 365
Thr Lys Lys Thr Cys Ala Tyr Thr Asn His Thr Val Leu Pro Glu Ala
370 375 380
Leu Glu Arg Trp Pro Val Ser Met Phe Glu Lys Leu Leu Pro Arg His
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Leu Glu Ile Ile Tyr Ala Ile Asn Gln Arg His Leu Asp His Val Ala
405 410 415
Ala Leu Phe Pro Gly Asp Val Asp Arg Leu Arg Arg Met Ser Val Ile
420 425 430
Glu Glu Gly Asp Cys Lys Arg Ile Asn Met Ala His Leu Cys Val Ile
435 440 445
Gly Ser His Ala Val Asn Gly Val Ala Arg Ile His Ser Glu Ile Val
450 455 460
Lys Gln Ser Val Phe Lys Asp Phe Tyr Glu Leu Glu Pro Glu Lys Phe
465 470 475 480
Gln Asn Lys Thr Asn Gly Ile Thr Pro Arg Arg Trp Leu Leu Leu Cys
485 490 495
Asn Pro Gly Leu Ala Asp Thr Ile Val Glu Lys Ile Gly Glu Glu Phe
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Leu Thr Asp Leu Ser Gln Leu Lys Lys Leu Leu Pro Leu Val Ser Asp
515 520 525
Glu Val Phe Ile Arg Asp Val Ala Lys Val Lys Gln Glu Asn Lys Leu
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Lys Phe Ser Ala Phe Leu Glu Lys Glu Tyr Lys Val Lys Ile Asn Pro
545 550 555 560
Ser Ser Met Phe Asp Val His Val Lys Arg Ile His Glu Tyr Lys Arg
565 570 575
Gln Leu Leu Asn Cys Leu His Val Val Thr Leu Tyr Asn Arg Ile Lys
580 585 590
Arg Asp Pro Ala Lys Ala Phe Val Pro Arg Thr Val Met Ile Gly Gly
595 600 605
Lys Ala Ala Pro Gly Tyr His Met Ala Lys Leu Ile Ile Lys Leu Val
610 615 620
Thr Ser Ile Gly Asp Val Val Asn His Asp Pro Val Val Gly Asp Arg
625 630 635 640
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645 650 655
Val Ile Pro Ala Ala Asp Leu Ser Gln Gln Ile Ser Thr Ala Gly Thr
660 665 670
Glu Ala Ser Gly Thr Gly Asn Met Lys Phe Met Leu Asn Gly Ala Leu
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Thr Ile Gly Thr Met Asp Gly Ala Asn Val Glu Met Ala Glu Glu Ala
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Gly Ala Glu Asn Leu Phe Ile Phe Gly Leu Arg Val Glu Asp Val Glu
705 710 715 720
Ala Leu Asp Arg Lys Gly Tyr Asn Ala Arg Glu Tyr Tyr Asp His Leu
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740 745 750
Pro Lys Glu Pro Asp Cys Phe Lys Asp Ile Val Asn Met Leu Met His
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His Asp Arg Phe Lys Val Phe Ala Asp Tyr Glu Ala Tyr Met Gln Cys
770 775 780
Gln Ala Gln Val Asp Gln Leu Tyr Arg Asn Pro Lys Glu Trp Thr Lys
785 790 795 800
Lys Val Ile Arg Asn Ile Ala Cys Ser Gly Lys Phe Ser Ser Asp Arg
805 810 815
Thr Ile Thr Glu Tyr Ala Arg Glu Ile Trp Gly Val Glu Pro Ser Asp
820 825 830
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templst
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